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THE STATUS OF THE NATION'S HIGHWAYS: CONDITIONS AND PERFORMANCE

REPORT

OF THE

SECRETARY OF TRANSPORTATION

TO THE

UNITED STATES CONGRESS

Pursuant to Section 307 of Title 23, United States Code

JULY 1983

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LETTER OF TRANSMITTAL

THE SECRETARY OF TRANSPORTATION
WASHINGTON, D.C. 20590

JUL 6 1983

The Honorable Thomas P. O'Neill, Jr.
Speaker of the House of Representatives
Washington, D.C. 20515

Dear Mr. Speaker:

The enclosed report, "The Status of the Nation's Highways: Conditions and Performance," is submitted in response to Section 307 of Title 23, United States Code. This is the seventh in a biennial series of reports to Congress on the Nation's highway needs.

The report assesses the quality of highway service as reflected by objective conditions and performance measures and describes changes in those measures in recent years. In addition, the report estimates future capital spending, irrespective of governmental jurisdiction, required to achieve various levels of future highway service.

It should be noted that information and observations presented here are based on data obtained through 1981 and do not totally reflect the impact of the Surface Transportation Assistance Act of 1982.

Sincerely,

Elizabeth H. Dole

Elizabeth Hanford Dole

Enclosure

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Summary

THE STATUS OF THE NATION'S HIGHWAYS: CONDITIONS AND PERFORMANCE 1983

INTRODUCTION

This is the seventh in a series of reports submitted to Congress pursuant to Section 3 of P.L. 89-139 (Section 307(a) of Title 23, United States Code) which specifies a requirement for biennial reports on the present condition of the Nation's highways and the Nation's future highway needs.

The purpose of the 1983 report is to describe what has transpired during the recent past in terms of highway financing and the resulting changes in highway conditions and performance achieved by capital investment during those years. The report also contains projections of investment-performance relationships through the end of the century and a discussion of issues specifically related to the Federal-aid highway program. It should be noted that the observations in this report were made well in advance of the passage of the Surface Transportation Assistance Act of 1982. Thus, the additional highway revenues which will be provided by the 5 cent equivalent user fee increase, and their expected significant impact on the condition of the Nation's highways, could not be entirely reflected.

There is no question that highway transportation plays a major role in the intricate interaction of activities within the Nation's economy. Highway transportation also is essential to the rapid deployment of our national defense capabilities. At the same time, it provides each individual with access to all the activities performed in daily living. In other words, highways are essential to our Nation, to each region of the country, to each State, and finally, to each locality.

For some time, the Administration has been reviewing Federal programs to determine which are truly a Federal responsibility and which ones are more appropriately the responsibility of State and local government. In this federalism review, the Administration consulted with State and local officials and the congressional leadership.

On February 24, 1983, the Administration submitted the federalism initiative legislation to Congress, of which one of the four parts is a transportation block grant for highway programs which receive Federal funding but predominantly benefit the residents of the separate States. These programs are the urban system, the secondary system, bridges other than primary and high cost bridges, the highway safety program administered by the Federal Highway Administration (FHWA), the hazard elimination program and the rail-highway crossings program.

During the period of the legislation, through fiscal year (FY) 1988, States would have the choice of continuing to receive the funds for these programs under the existing statutory mechanisms or receiving them in the form of a block grant. The amount that a State would receive under the block grant is equal to the sum of what it would receive from the individual programs included in the block grant. The large urbanized areas, with a population of 200,000 or more, will receive funds in accordance with established formulas, that are proportional to amounts they would have received under current programs.

If all the States chose the block grant, the amount would total the amount authorized for eligible States in FY 1984. The funds can be used on any project that could have received Federal-aid highway funding under Title 23 and thus cannot be used for routine operating costs such as grass-cutting and electricity for street lights.

The block grant is designed to remove unnecessary restrictions on State decisionmaking and to give States the flexibility to respond to special circumstances. The Federal Government's role in highway programs that benefit the Federal interest--primary and Interstate roads and bridges and high cost briges--would remain unchanged.

During the 5-year period, the Administration will determine whether it is feasible to return revenue sources, such as Federal excise taxes or a percentage of the Federal income tax, to State and local governments commensurate with funding for the programs in the block grants. The President will establish a presidential commission to make recommendations on revenue return issues.

Scope

This report covers two time periods. The first is the period 1975-1981 and includes information about highway finances and highway conditions and usage compiled in 1975, 1978, and 1981. The second is the period from 1980 through 2000. The report views highway issues primarily from a national, or aggregate, perspective, although certain sections illustrate that there is a wide variance in highway conditions among individual States. The report concentrates on the performance and condition of the Nation's arterials and collectors. This is not because the local road mileage is without problems, but because the Federal role, as delineated by Congress, has focused on arterials and collectors.

Finally, the nature of the data collected for this report limits the level of detail to the more prominent Federal categorical programs, such as the Interstate, primary, secondary, urban, and bridge. Federal-aid program discussions contained in Chapter V, therefore, are aimed at these five major categories which account for over 80 percent of the Federal-aid highway funds.

Information Sources

The Federal Highway Administration (FHWA) and the States have jointly developed and implemented a data system called the Highway Performance Monitoring System (HPMS) which supplies timely information about the condition and use of the major highway systems and about the capital investment being made to improve these highways. The HPMS is the primary source of information contained in this report. In the future, HPMS will supply those involved in highway program development and management a continuous picture of how and where highway conditions are changing and how investment levels and patterns are related to the changes.

HIGHWAY FINANCE TRENDS

Highway financing is a complex network of revenue transfers involving thousands of individual jurisdictions, using a variety of revenue raising mechanisms, to finance a wide range of highway activities, including operation and capital improvements. It is a

dynamic network, and any change in it directly affects the performance of the highway system.

Preliminary figures for 1981 and 1982 indicate that in terms of constant dollars, total highway disbursements had the same relative purchasing power in those years as they did in 1978. While current dollar investments increased by 22 percent between 1978 and 1982, inflation in the highway industry, as measured by the Bid Price Index (BPI), rose nearly 37 percent from 1978 to 1980. Since early 1980, however, an 11 percent decrease in the BPI has helped to compensate for both the earlier rapid price escalation, and a slight downward turn in total disbursements in 1981 and 1982.

While the cost of operating, maintaining, and improving the major highway systems was increasing, revenue to cover these costs has been diminishing. A shift in the vehicle fleet toward greater fuel efficiency and a reduction in auto use toward the end of the decade caused motor-fuel tax receipts to decline as a share of total highway revenue. This reduction in motor-fuel tax receipts has slowed the growth in total highway investment.

While highway-user fees have continued to supply the major portion of highway revenue, the percentage declined from 72 percent in 1978 to 67 percent in 1982. From the Federal perspective, other agencies provided a minor, but increasing share of the funds available for expenditure on highways. These included general revenue sharing, Department of Housing and Urban Development (HUD) block grants, and Economic Development Administration (EDA) grants.

The share of total highway funds expended for capital improvements has diminished steadily while expenditures for noncapital functions, including law enforcement, bond retirement, operations, and maintenance, have increased. Capital spending in 1982 is expected to be 45 percent of total expenditures, down from 53 percent in 1972. This shift in priority away from capital investment, coupled with declining real value of investment has resulted in a significantly reduced national capital investment program. Capital investment is any highway activity other than operations or maintenance, including construction, reconstruction, major widening, bridge improvements, or 3R (rehabilitation, restoration, and resurfacing). Maintenance includes paint striping, snow removal, minor patching, grass cutting, and other activities requiring major personnel costs.

Although capital investment on the Interstate (excluding Interstate completion financing) has been increasing steadily since 1975, the other urban and rural arterials receive the largest share. The impacts of this investment pattern are clearly evident in the physical changes taking place on the various systems.

The Federal share of total highway revenue in 1982 (prior to enactment of the STAA) was the lowest in 20 years. Despite increases in user fees by over half the States since 1980, total revenue showed little growth, primarily because of the increased fuel efficiency of the motor-vehicle fleet.

Investment trends by type of improvement remain essentially as they were reported in 1981. New contruction and major reconstruction declined as a percentage of the total capital investment while resurfacing and rehabilitation improvements increased. This shift away from added capacity was most notable in rural areas. In urbanized areas, the move away from heavy construction was also evident, but there remains a strong interest in reconstruction and major widening of higher order facilities.

HIGHWAY CONDITIONS

Chapter III describes how the trends in capital expenditure have affected highway conditions. The chapter summarizes changes in conditions and performance since 1975, based on extensive field surveys undertaken cooperatively by FHWA and the States. The chapter addresses only the nonlocal functional systems. These highways account for only 30 percent of national highway mileage, but carry 86 percent of national highway travel.

Data on pavement condition and congestion were combined into a deterioration index (DI) to measure the aggregate effect that increased travel has had on the major highway systems. The DI was computed for three time periods (1975, 1978, and current) and was weighted both by miles and by travel. The results are as follows:

Average Deterioration Index for All Systems

	1975	1978	Current
DI (weighted by miles)	70.6	70.3	69.4
DI (weighted by travel)	60.3	59.6	57.7

This index describes a gradual downward trend in highway performance over the 6-year period for which data are available. Although certain highway systems have experienced improvement in a particular area such as pavement condition or congestion, the combined effect has been toward deterioration. This could be anticipated, in view of the increase in demand and reduced investment in constant dollars over the period.

Interstate

Approximately 3,000 miles of authorized Interstate (10.0 percent) in rural areas and 638 miles (7.4 percent) in urban areas were added since 1975. The pavement should be in very good condition on all this new mileage, which accounts for 9.5 percent of the entire System. Despite this increase in new and presumably very good mileage, rural Interstate mileage with a high PSR[1/] decreased by 2,300 miles. Over 3,200 miles (9.9 percent of the System) are at or below a PSR of 2.5, while an additional 4,300 miles (13.2 percent) have PSR's that indicate major improvements will be needed soon.

Deterioration on the urban Interstate has also taken place. Mileage with a high PSR decreased slightly since 1975 despite the 638 new miles, although some increase has been measured since 1978. The mileage at or below a PSR of 2.5 increased to 1,145 miles since 1975 or 12.3 percent of the urban Interstate.

1/ Present serviceability rating (PSR) is a rating for pavement conditions. A PSR of 4.0 or higher indicates new or nearly new pavement. A PSR of 3.0 indicates pavement in fair condition but in a state of accelerating deterioration. A PSR of 2.0 (2.5 for Interstate) is the point that separates pavement in fair condition from pavement needing repair.

Congestion, as measured by high volume-to-capacity (V/C) ratios, increased since 1975 on the urban Interstate: 48.5 percent of urban peak-period travel on the Interstate now experiences high V/C ratios, compared to 40 percent in 1975 and 47 percent in 1978. Overall safety performance on the Interstate has been stable since 1975. A small increase in the fatality rate on urban mileage has been offset by a decline on rural mileage.

Arterials

Pavement condition improved on rural arterials since 1975, although considerable needs remain. Mileage currently at or below a PSR of 2.0 increased slightly (by 225 miles), but the mileage that is approaching this point decreased by almost 6,500 miles. Mileage with a high PSR increased by almost 7,000 miles to 26 percent of the system.

The change on urban arterials was mixed. Mileage currently at or below a PSR of 2.0 increased from 9 percent to 11 percent since 1975 (to 12,600 miles). However, the mileage approaching this point decreased since 1978, while mileage with a high PSR increased from 20,200 miles to 26,400 miles (22 percent).

Safety performance improved on all non-Interstate arterials. Fatality rates on the Interstate and other arterials combined, decreased by an annual average of about 1 percent since 1975. The general improvement in pavement and safety on arterials reflects the high priority arterials receive in State capital programs. Capital investment per unit of vehicle travel on arterials approaches that on the Interstate and virtually all this capital has been invested on existing mileage, as system expansion has been very limited. Consequently, the type of investments made tend to improve both pavement conditions and geometric characteristics. Other safety measures such as the 55 m.p.h. speed limit have also contributed greatly to the reduced fatality rate.

Congestion on urban arterials has stabilized. Currently, 42 percent of peak-period travel on all urban arterials experiences high V/C ratios. Peak-period congestion remains low on rural arterials, but has incresed steadily since 1975. In 1981, 3 percent of the miles and 8 percent of peak-period travel operated under congested conditions.

In general, congestion has brought about a gradual deterioration in overall performance on both rural and urban arterials since 1975.

Collectors

Overall pavement condition improved since 1975, but the change since 1978 has been more dramatic. It appears that, nationally, accelerated investment in 3R improvements has reversed the trend of pavement deterioration on a majority of collector routes.

In rural areas, congestion during peak periods of travel has been increasing since 1975, although in 1981 only 5 percent of peak-period travel occurred under congested conditions. In urban areas, collector system congestion also increased since 1975, affecting 26 percent of travel on these routes.

Fatality rates on both rural and urban collectors are higher than on arterials in comparable areas. This is due, primarily to lower geometric standards and relatively few miles of 4-lane facilitites.

When factors affecting deterioration are considered together (pavement and operating conditions), the condition of collectors, both urban and rural, has deteriorated since 1975.

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HIGHWAY NEEDS: 1980 - 2000

The long-term performance of the highway system will be a function of both future travel and capital investment. Chapter IV discusses anticipated travel through the year 2000 and estimates the effects of that travel on system conditions and performance. Table S-1 summarizes capital investment needs through the year 2000 (1) to eliminate all deficiencies that currently exist or can be expected to accrue through the year 2000 and (2) to maintain conditions through the year 2000 as they were in 1980. These estimates are provided for two levels of travel to illustrate the relationships between investment needs and travel.

Even at these levels of investment, shown on Table S-1, performance can be expected to decline in urban areas, especially where right-of-way constraints preclude solving congestion problems with traditional additions to highway capacity. Future capacity needs in many urban areas must be met by innovative traffic management strategies, transit, or changes in historical commuting patterns. Physical improvements to urban highways will continue to be made, but more in the form of resurfacing and rehabilitation rather than extensive new freeway construction.

Chapter IV also discusses deferred capital cost, the additional cost of delaying needed improvements. Total deferred cost is relatively small, approximately 3 percent of the cost to maintain conditions. However, for specific projects, significant delays in meeting a need allow increased deterioration to occur, and can increase the cost of restoring serviceability on that segment by up to 240 percent. Chapter IV also contains estimates for bridge repairs and the cost of completing the Interstate, estimates previously excluded from these reports and addressed in separate reports to Congress.

Chapter IV describes only total capital requirements on the existing highway network through the end of the century, except for local road needs, for which data are unavailable. Estimates for new highway construction (other than Interstate gaps) are not included. New construction is a function of the availability of capital and there is no analytical means of estimating where, and to what extent, new construction will occur.

THE FEDERAL HIGHWAY PROGRAM

The Federal-aid highway systems are subsets of the various functional systems. For example, the primary system is comprised of virtually all rural arterials and approximately 25 percent of urban arterials. The secondary system accounts for 91 percent of rural major collectors. The urban system is a mixture of urban arterials and collectors, representing almost 70 percent of the total urban arterial and collector mileage. Together, these systems plus the Interstate which, of course, is self-defined, account for 828,526 of the 1,199,559 miles of nonlocal road, or 69 percent, and carry 92 percent of nonlocal highway travel. (Local roads which provide only land access and other types of strictly private travel, are not included in discussions of public highways and travel.)

In general, the Federal highway systems reflect the same degree of change since 1975 that was found on the functional systems. New mileage has been added to the

Interstate System, and the high quality of these miles tends to offset deterioration on the older mileage, when the system is viewed in the aggregate. Despite this new mileage, approximately 7,600 miles of rural Interstate have serviceability ratings that indicate the need for major capital improvements now or in the near future, and 3,200 miles definitely need some repair now. In urban areas, conditions have deteriorated even more. Mileage requiring attention now, or in the near future has increased by 60 percent since 1975 to slightly more than 2,300 miles.

The primary system carries approximately 34 percent of all travel on 21 percent of the nonlocal miles. It ranks in importance only behind the Interstate System as a provider of interstate transportation. In fact, it provides the highest quality of highway service available to many rural areas of the country. Currently, over 10 percent of the primary system pavement is at or below a PSR of 2.0, while an additional 30 percent, or over 110,000 miles, will require investment in the near future. Excluding the Interstate, the primary system is in relatively better shape than the other systems, primarily because of increased State attention to the system's needs.

The urban system was established in 1970 as an attempt to respond to urban needs. Today it is made up of freeways, principal and minor arterials, and collectors. While the name implies a network of city streets and highways, about half of urban system mileage is actually in suburban areas.

Approximately 11 percent, or 15,100 miles, of the urban system is at or below a PSR of 2.0. In the near future, 50,000 miles of pavement will drop into this category.

The secondary system was established in 1944 as a farm-to-market system. It grew out of an effort, begun in the depression, to put people to work paving rural roads. The system was realigned by Congress in 1976 to include only rural major collectors, roads that serve county seats, major farms, and some industries located in rural areas. The system carries 21 percent of all rural travel.

The secondary is in the poorest condition of all systems. Given its extent (401,000 miles) and its relatively light usage, it is not surprising that the secondary is in poor shape, particularly when other, more heavily used, roads compete for scarce funds. Almost 40 percent of the secondary paved mileage either requires, or will shortly require, capital improvement. The extent of secondary mileage with pavement in good condition has improved since 1975, reflecting a concentration of capital on 3R improvements between 1975 and 1981, and the realignment of the system in 1976.

Bridge conditions vary by system, much like highway conditions. Bridges are evaluated by a sufficiency rating that determines eligibility for improvement under the bridge program. Nearly half the Nation's highway bridges exhibit some type of deficiency, categorized as structural, functional, or inability to perform an essential function. 1/ Structural and deck geometry deficiencies are most common. As of December 31, 1981, some 3,150 Interstate, 20,000 primary, 30,000 secondary, and 7,900 urban bridges had sufficiency ratings establishing eligibility for replacement or rehabilitation. Almost 3,700 additional bridges on Federal-aid systems will reach eligibility each year.

1/ Example: A 30-year old bridge designed and built for 10-ton loads is now required to carry 20-ton loads. Therefore, it is now structurally inadequate, although, in very good structural condition.

Table S-2 provides estimates through 2000 for maintaining conditions on the primary, secondary, and urban systems, completing and maintaining the Interstate through 4R, and meeting only backlog needs on bridges.

IMPACT OF THE STAA OF 1982

The passage of the STAA of 1982, which increased the Federal fuel tax to 9 cents per gallon, marked a significant increase in Federal capital investment on the Nation's highway systems, an interest that had waned gradually over time due to the fixed 4 cent Federal gas tax and highway-use fees, and the inflationary nature of the 1970's economy. This increase will produce an additional $4.4 billion per year in highway revenues. The years 1983 through 1986 should produce several signficant changes in highway financing trends that have developed since 1970. Federal highway revenues, as a percent of total collections for highway purposes by all levels of government, should reverse their downward trend of the past 20 years. Overall growth in highway capital investment will accelerate compared to past growth rates. And, again at the Federal level, the percentage of revenues financing highway improvements, that is derived from user charges, is expected to increase.

The STAA will provide sufficient funds to complete the Interstate System in the early 1990's, meet all Interstate 4R pavement needs and most capacity needs, and provide assistance to States in meeting redefined Interstate needs. It will also provide sufficient Federal aid to maintain conditions on the primary system, assuming States approximate their historic share of primary capital investment. These two systems fulfill the requirements generally held to represent the highest priority for a Federal interest, such as density of travel, interstate commerce, regional connectivity, and defense preparedness. The STAA of 1982 also substantially increases Federal funding for the repair or replacement of deficient bridges and provides a moderate level of funding for the urban and secondary systems. Table S-3 compares annualized anticipated capital investment by all levels of government with annualized systems needs through 2000.

HIGHWAYS AND THE ECONOMY

The effects of highway spending can be traced through the economy in two ways. First, direct capital spending influences employment in several key industries engaged in highway construction and in providing construction materials. These expenditures also influence private investment in vehicle stocks, tax generation, and personal and corporate consumption of highway services. Second, and the underlying reason that highway spending occurs, is that changes in conditions and performance affect costs to users, and those costs can be measured and traced through the economy. Chapter VI describes the macroeconomic effects of highway investment and identifies those industries that are affected by changes in conditions and performance.

In general, this chapter shows that increasing highway spending from pre-1983 levels to those required to maintain performance would result in measurable benefits to the gross national product (GNP) and labor productivity. These benefits would be precipitated by reductions in vehicle operating cost and travel times which would translate into changes in vehicle depreciation, enroute inventories, and trucking productivity.

Chapter VI also addresses shifts in interindustry output and sales and the effects of changing highway performance on personal consumption expenditures and gross domestic investment. The gist of the chapter is that, in the long-term, highway improvements result in a substantial net economic gain.

Needs on the Federal-aid system are increasing (Table S-2). Assuming an average annual VMT growth of 2.8 percent a combined Federal, State, and local capital investment of $427.5 billion (1980 dollars) will be required over 20 years if five principal objectives are to be met: (1) arrest deterioration of the system ($282.7 billion); (2) complete the Interstate ($37.8 billion); (3) meet redefined Interstate needs ($14.9 billion); (4) eliminate the backlog of bridge needs ($45.9 billion); and (5) meet anticipated accruing bridge needs ($46.2 billion). This would require an annual average of $21.4 billion (1980 dollars), which is roughly 50 percent greater than the total capital invested by all levels of government on nonlocal roads in 1980. Assuming a lower average annual growth in travel of 2.0 percent, the equivalent total would be $398.9 billion, or $19.9 billion per year.

Table S-1
Estimated 1981-2000 Capital Investment Requirements* on all Functional Systems
(In billions of 1980 dollars)

Annual Rate of Travel Growth	Full Needs				Maintain 1980 Conditions			
	Urban	Rural	Total	Annual Cost	Urban	Rural	Total	Annual Cost
2.8%	162.11	293.89	456.00	22.8	130.69	183.73	314.42	15.7
2.0%	150.06	277.37	427.43	21.4	109.94	175.82	285.76	14.3

* Excludes Interstate completion, local road needs, and most backlog bridge needs and all accruing bridge needs.

Table S-2
Estimated 20-Year (1981-2000) Federal-Aid System Capital Requirements[1/]
(In billions of 1980 dollars)

Category	Total Dollars	Source
Interstate completion	37.8[2/]	Adjusted 1983 estimate of the cost of completing the National System of Interstate and Defense Highways
Interstate 4R	58.7 - 56.1 (2.9)[3/] (2.8)	1983 Status of the Nation's Highways: Conditions and Performance
ICE redefinition (costs dropped from Interstate Cost Estimate pursuant to 1981 Highway Act)	14.9 (0.7)	Adjusted 1981 Estimate of the cost of completing the National System of Interstate and Defense Highways
Primary	91.6 - 82.4 (4.6) (4.1)	1983 Status of the Nation's Highways: Conditions and Performance
Secondary	75.3 - 69.2 (3.8) (3.5)	1983 Status of the Nation's Highways: Conditions and Performance
Urban	57.1 - 46.4 (2.9) (2.3)	1983 Status of the Nation's Highways: Conditions and Performance
Subtotal	335.4 306.8 (16.8) (15.3)	

Estimated Bridge Needs - December 31, 1981

Bridge[4/]		
Primary	9.9	Third Annual Report to Congress, March 1982, bridge replacement and rehabilitation program
Secondary	6.7	
Urban	6.3	
Off-system	23.0	
Subtotal	45.9 (2.3)	
Total	381.3 - 352.7 (19.1) (17.6)	

1/ I-4R, primary, secondary, and urban capital requirements based on average annual travel growth of 2.8 and 2.0 percent, respectively.

2/ Based on completion needs as of January 1, 1982.

3/ Average annual capital requirements in ( ).

4/ Existing bridge needs only--does not include accruing deficiencies.

Table S-3
Estimated 17-Year (1984-2000) Federal-Aid System Capital Requirements
Compared with Anticipated Investments Resulting from the
STAA of 1982 1/ 2/ 3/
(In billions of 1980 dollars)

Category	Total Dollar Needs			Anticipated Investment 1983 through 1986
Interstate Completion	34.33 (3.81)		34.33 (3.81)	15.24 (3.81)
Interstate 4R and Redefinition	53.22 (3.13)		50.62 (2.98)	10.50 (2.63)
Primary	79.38 (4.67)	-	70.18 (4.13)	14.66 (3.67)
Secondary	71.43 (4.20)	-	65.34 (3.84)	6.26 (1.57)
Urban	51.48 (3.03)	-	40.78 (2.40)	7.43 (1.86)
Subtotal	289.84 (18.84)		261.25 (17.16)	54.09 (13.54)
Bridge				
Primary	9.28		9.28	1.81
Secondary	6.28		6.28	1.20
Urban	5.90		5.90	1.12
Off-System	21.96	-	21.96	4.10
Subtotal	43.42 (2.55)	-	43.42 (2.55)	8.23 (2.06)
Minimum Allocation (Section 150, of 1982 STAA)				2.14 (.54)
TOTAL	$ 333.26 (21.39)	-	304.67 (19.71)	64.46 (16.14)

1/ Assumes that the Federal share of total anticipated investments increases between 1983-1986 compared to past trends reported in the 1981 Status of the Nation's Highways: Conditions and Performance Report. The assumption is that State capital investment between 1983 and 1986 would increase only enough to provide additional matching fund increases resulting from the expanded Federal program.

2/ Figures in parenthesis are in average annual 1980 dollars. Average annual needs for Interstate completion are computed on a 9-year time period. All other annual needs are computed on a 17-year time period. All average annual anticipated investments are computed on a 4-year time period.

3/ I-4R, primary, secondary, and urban capital requirements based on average annual travel growth of 2.8 and 2.0 percent, respectively.

Chapter I
INTRODUCTION

Purpose

The highway financing partnership between Federal, State, and local jurisdictions has now been in place for over 60 years, with changing roles and changing priorities as the various highway systems were developed.

In 1981, approximately $39 billion was disbursed by all levels of government for highway-related activities, including capital improvements, maintenance, administration, and enforcement. Twenty-eight percent of this or $10.7 billion, was supplied by the Federal Government, for the most part to States and local jurisdictions to aid in the combined effort of maintaining conditions and performance on the Nation's major highway systems.

As Congress develops Federal highway legislation, it needs information concerning the magnitude of highway investment, who participates in the investment and to what degree, what the investment is for, the impact of the investment, and what future investment will be required. This report provides the latest available information.

Review of Previous Reports

Pursuant to the requirements of Section 3 of P.L. 89-139, a series of reports dealing with highway needs has been prepared for Congress by the Secretary of Transportation. The first report, published in February 1968, confidently anticipated early completion of the Interstate System and indicated that States anticipated the need for an additional 40,000 miles of freeway. It noted, with some concern, that the bid price was rising at a rate of 3 percent annually (it rose 21 percent in 1978). It also said that ". . . more extensive assistance by the Federal Government toward the solution of internal urban transportation problems appears warranted."

The 1970 report, published in September 1970, recognized that the goal to complete the Interstate System by 1972 could not be achieved since only 55 percent of the 42,500-mile System was complete as of September 1969. It also hinted at issues surrounding the role of the freeway in urban development programs. It pointed out that in some areas freeways were becoming a controversial issue.

The 1972 report contained the results of a nationwide needs study that projected the 20-year costs associated with eliminating all deficient highways throughout the country. The study reflected the thinking that was prevalent at that time, which was to raise the level of service provided by the highways.

The two reports that followed began to reflect the many changes taking place in the 1970's throughout the country that were affecting both Federal and non-Federal investment programs for highways. The 1974 report introduced the idea that "performance" was the ingredient by which to measure the effectiveness of highway investments. The 1977 report expanded on this idea and quantified the relationships between differing investment levels and highway performance. It was becoming apparent by the mid-1970's that changing national priorities, inflation, and continued auto travel growth were combining to make it impossible to fund the cost of removing all highway deficiencies by 1990.

The last report, in 1981, continued that approach by defining full needs as only those improvements necessary to achieve minimum condition standards. The report concluded that, if highway investment continued to grow at its present insufficient rate, overall conditions and performance would decline.

Changing Roles and Priorities

The Federal role in highways has evolved over a period of 66 years, since the Federal Aid Road Act of 1916 formalized a Federal concern for the basic primary system of roads. Since that time, systems and mileage eligible for Federal aid have been added, and the rural post road system of 6,200 miles envisaged by the 1916 Act has grown to a multisystem program exceeding 800,000 miles. In some instances, the designation of a system or creation of a program has followed a general recognition of Federal responsibility. In others, the presumption of Federal responsibility has followed the creation of the system or program. The present policy of "New Federalism" is causing all levels of government to reevaluate responsibilities and priorities related to the entire array of public programs currently supported by taxes and other public fees.

Two major issues facing not only the Federal Government, but all participants in the highway partnership today involve (1) examining current roles, relationships, and priorities related to highway investment and operations and (2) providing sufficient revenue for financing highway improvements at a rate that will at least restrict further deterioration.

Information Sources

The objective of this series of biennial reports is to provide Congress with timely information on the progress of the Federal-aid highway program. The FHWA and the States, beginning in 1978, jointly developed and implemented a continuous data collection system called the Highway Performance Monitoring System (HPMS), which supplies time series information about the condition and use of the major highway systems and the characteristics of capital investment to improve these facilities. With this information,which the States are now supplying on a regular basis, the performance of the Nation's highways and highway investment characteristics is monitored over time to provide decisionmakers with a current picture of the effectiveness of Federal, State, and local investment in highway capital improvement.

The information supplied by HPMS will give those involved in highway program development and management a continuous picture of how and where highway conditions and performance are changing and how investment levels and patterns are corresponding to such changes. The HPMS data will also be used to measure the impact of such policies as increasing emphasis on repairing existing highways and bridges and will form the basis for future reports to Congress on the status and changing needs of the Nation's highway systems.

Some information, such as that on bridge conditions and bridge needs, comes from sources other than the HPMS because the level of detail provided by those sources is better suited to considerations in these special areas. This is also true for past travel trends and some historical information on financing highways.

Scope

This report addresses broad Federal highway program issues, including national highway financing trends, major highway system conditions and performance, future highway investment/performance relationships, Federal-aid highway system status, and the relationship of the Nation's highways to the national economic structure.

Development of America's major highway systems reflects a combination of individual State priorities and concerns plus an overlying national interest that encourages system connectivity and uniformity. This report views highway issues primarily from a national, or aggregate, perspective, although the basic data have been provided by the individual States. When regional configurations and activities appear to have significant impact on national issues, the analyses and information reflect this national subdivision.

Urban development and issues related to that development, such as transportation, are unique and localized. Yet, the impact of such issues collectively dominates the national scene. A major objective of national transportation policy today is to reverse the forces that have led to economic stagnation of the center city. In rural areas, where the sheer magnitude of the system creates a problem, the concerns are less with development and more with preventing physical deterioration. Because of the basic differences in highway issues, the report material is subdivided into urban, small urban, and rural categories.

The Nation's roads and streets vary widely in the functions they perform. At the low end of the scale is the local road, which is used primarily for access to individual homes and land. At the other end of the scale is the freeway, which provides a high level of performance for longer trips. Local roads include about 69 percent of total road mileage but carry less than 17 percent of the Nation's highway travel. The Interstate System, on the other hand, constitutes 1 percent of the total mileage but carries 20 percent of the travel. In 1973 Congress realigned the Federal-aid highway systems along functional lines. Today, the Federal-aid primary system is comprised of arterials designed to provide high mobility. The secondary system consists of those major collector routes in rural areas that tie the arterials to the low volume local roads and streets. The Federal-aid urban system is a combination of arterials and collectors that provide the major supporting highway network in urban areas. (A more definitive description of Federal-aid systems and functional systems is provided at the end of this chapter.) This report concentrates primarily on the performance and condition of the Nation's arterials and collectors, not because the local road system is without problems, but because, from a national perspective, the Federal role in the higher order systems has been clearly delineated by Congress.

The Federal-aid highway program provides funds for over 40 special categories of highway improvements. These categories also vary by eligibility, e.g., the primary program provides for a variety of improvements made exclusively on highways on the primary system while the bridge program provides for a limited number of bridge improvements on a wide variety of highway functional systems. The nature of the data collected for this report limits the report to the larger categorical programs such as Interstate, primary, secondary, urban, and bridge. Federal-aid program discussions, therefore, are associated primarily with the five or six largest funding categories comprising over 80 percent of the Federal highway funds.

Organization of this Report

The first part of this report concentrates on general highway transportation and the condition and performance of the integrated highway systems at the national level. Chapter II describes the changes in highway financing and investment during the past two decades. It examines the effects of inflation as the various jurisdictions attempt to buy more system performance with available funds. It tracks highway investment patterns of the 1970's, showing how trends in maintenance, capital investment and operating costs were changing.

Chapter III contains information about the trends in travel characteristics and the physical condition of today's highway systems. The first part of the chapter deals with mileage and travel stratified by functional and Federal-aid systems. The second part of the chapter describes the physical condition of our major highway systems, and, where possible, attempts to quantify the changes in physical and operating conditions that have taken place since 1975. Finally, the chapter provides information on how the changes in physical and operating conditions have affected user costs since 1975 and 1978.

Chapter IV gives the results of an analysis that estimated future highway condition changes and the investment required to achieve various performance levels. The analysis tested the relationships between future travel, future investment, and future highway conditions for two levels of highway performance. The higher level tested was "full needs," which represents a highway system having no poor pavement, no congestion, no alignment problems, etc. In short, a condition where there are zero problems, although not all mileage would be at full design standards. The other level tested was "maintain current conditions," which represents a composite system much like it is today, a system in basically good shape, with a certain percentage of roadway needing some improvement. The sensitivity analysis examines the investment/performance relationships and estimates the costs of achieving these two performance levels.

Chapter V concentrates on the Federal-aid highway systems. Material for this chapter was extracted from the prior chapters on financing, physical inventory, and future investment/performance relationships on the functional systems and is summarized and recompiled to allow the reader to view all aspects of Federal-aid highway activities.

Chapter VI addresses the relationship between highway transportation, highway performance, and the Nation's economy. It includes the results of a study conducted by FHWA that measures the sensitivity among highway investment, highway user costs, and major economic indicators.

Definitions of the Highway Systems

Federal-Aid Systems

- The National System of Interstate and Defense Highways - consists of routes of highest importance to the Nation that connect, as directly as possible, the principal metropolitan areas, cities, and industrial centers, including important routes into, through, and around urban areas; serve the national defense and, to the greatest extent possible, connect at suitable border points with routes of continental importance in Canada and Mexico. The Interstate System is a subsystem of the primary system.

- o The Federal-Aid Primary System - consists of a system of interconnected main roads important to interstate, statewide, and regional travel, consisting of rural arterial routes and their extensions into or through urban areas.
- o The Federal-Aid Secondary System - consists of rural major collector routes.
- o The Federal-Aid Urban System - consists of urban arterial and collector routes exclusive of urban extensions of the Federal-aid primary system.

Functional Systems

- o Principal Arterial System - in rural areas, a network of routes that primarily serve travel of statewide or interstate significance; that serve virtually all urban areas over 50,000 population; that provide high overall travel speeds with minimum interference to through activity; that serve the highest traffic volume corridors and the longest trip lengths; and that carry a high proportion of urban area travel.

  The principal arterial system is stratified as follows: (a) Interstate, (b) other freeways and expressways (in urban areas only), and (c) other principal arterials.
- o Minor Arterial System - in rural areas, a network of routes that provide access to principal arterial routes and, in conjunction with principal arterials, that link cities and larger towns to facilitate interstate and intercounty service.

  In urban areas, this system serves trips of moderate length at a somewhat lower level of travel mobility. Such routes interconnect with and augment the principal arterial system. They may carry local bus routes and provide intracommunity connectivity.
- o Collector System - in rural areas, a network of routes that generally serve travel of a localized nature and on which predominant travel distances are shorter than on arterial routes. The rural collector system is stratified as follows: (a) major collectors - serving county seats and other traffic generators not directly served by arterial routes, and (b) minor collectors - linking locally important traffic generators with smaller communities.

  In urban areas, such routes distribute trips to and from the arterials. Such routes provide for local traffic movement within residential neighborhoods, commercial areas, and industrial areas.

Chapter II
HIGHWAY FINANCE TRENDS

The January 1981 report to Congress, "The Status of the Nation's Highways: Conditions and Performance," discussed the history of highway capital investment from Federal, State and local perspectives, tracing the evolution in capital and noncapital outlays throughout the 1960's and most of the 1970's. This chapter continues the analysis into the early 1980's discussing the factors that have affected and will continue to affect the highway capital program during the next 5- to 10-year period.[1/] Trends evolving during the study period include:

- Total annual highway disbursements, in terms of current and constant dollars, have leveled off in recent years. While current dollar disbursements are estimated to be slightly less in 1982 than they were in 1980, this downturn has been offset by decreases in the BPI which have occurred since early 1980.
- Capital disbursements in constant dollars were lower in 1981 and 1982 than they have been in any years since the pre-Interstate era. Nationally, the share of total highway funds disbursed for capital improvements in 1982 is expected to be less than 45 percent, down from 53 percent 10 years earlier. A larger percentage of total revenues is being disbursed for maintenance, law enforcement, and other administrative needs, which are now receiving 47 cents of every dollar compared to 38 cents in 1972. Debt service continues to require more than 8 cents on the dollar.
- Federal highway revenues in 1982, as a percent of total collections for highway purposes by all levels of government, were the lowest they have been in over 20 years. Throughout the 1960's and 1970's, the Federal share of total highway revenue was approximately 27.5 percent; in 1982 it dropped to 24.4 percent.
- Total highway revenues in 1982 are expected to be 65 percent higher than in 1972, but in constant dollars, they will actually be worth 28 percent less.
- Despite increases in user fees by over half the States since 1980, total revenues collected have shown little growth. This can largely be attributed to a more fuel-efficient use of the motor-vehicle fleet. At the Federal level, revenue collections were declining, but will increase under the STAA of 1982.
- User receipts, as a percent of total highway revenues, have stabilized in recent years after a long period of decline. They are expected to provide 67 percent of all highway revenues in 1982 compared to nearly 72 percent in 1978, and 83 percent in 1960.

1/ As noted in the Summary of this report, the observations in this report were made prior to the passage of the Surface Transportation Assistance Act of 1982. Thus, the additional highway revenues that will be provided by the 5-cent equivalent user fee increase could not be reflected. However, a discussion of the likely impacts of those increased revenues has been added to the Summary Chapter. Also, the observations in this Chapter were made during mid-year 1982 and were based on information available at that time.

- o Capital investment on the Interstate System, exclusive of cost-to-complete, is increasing. There has been a decrease in share of total capital investment on the minor arterials and collectors relative to other systems.
- o The share of total capital investment expended for each type of improvement has changed little in recent years. In rural areas resurfacing, restoration and rehabilitation (3R) improvements still consume nearly a third (29.7 percent) of all highway capital investments. In urban areas, reconstruction (26.6 percent share) and new construction (22.8 percent share) activities continue to consume approximately half (49.4 percent) of all urban highway capital revenues.

HIGHWAY DISBURSEMENTS

Annual disbursements for highways since 1965 by all levels of government are shown in Table II-1. Total disbursements decreased in 1981 and showed no significant growth in 1982. While it is common for disbursement shares to fluctuate from year to year, especially at the Federal level, it is unusual for combined disbursements for highways by the various jurisdictions to not show at least a marginal increase from one year to the next. The recent decline in total disbursements is the result of decreases at both the Federal and local levels during 1981 and 1982. Nominal growth in State disbursements during those same 2 years did not offset the losses at the other government levels.

The investment in the Nation's highway systems includes not only construction and reconstruction activities, right-of-way acquisition, and the other capital improvement elements commonly associated with the highway construction industry, but also the daily operation and maintenance functions, such as "pothole" repair, snow removal, striping, grass cutting, law enforcement, highway marking and debt service.

Table II-2 provides a breakdown of highway disbursements by function by all units of government since 1970. The capital improvement program commanded the greatest share of highway disbursements during the heavy Interstate System construction years of the 1960's and early 1970's. The last decade, however, has witnessed a decline in capital outlays as a share of total highway disbursements. Maintenance, operations, and debt service have combined to demand a major portion of the highway dollar and the trend shows little sign of reversing or stabilizing (see Figure II-1). Figures II-2, II-3, and II-4 illustrate the trend from the State, county, and municipal perspectives, respectively, and point out the differences in program emphasis. At the county and municipal levels, maintenance commands the lion's share of highway activities, whereas capital disbursements have traditionally dominated the State's highway budget. However, for all units of government, capital disbursements have decreased in recent years while total disbursements for other highway purposes have continued to increase.

Figure II-5 illustrates the overall trend in highway disbursements, comparing the growth of the total program and the capital component in current dollars. Until 1980, total disbursements increased annually with the capital share increasing at a much slower rate. This disparity between total disbursements and the capital share has increased considerably since the mid-1970's. Since 1980 total disbursements have taken a slight downward turn, with the capital share dropping markedly, further increasing the disparity.

Effects of Inflation

Devaluation of highway disbursements due to inflation has had a major influence on the highway program. Figure II-6 compares the relative levels of capital disbursements in current dollars and in constant 1977 dollars, as reflected by the FHWA bid price index (BPI), a measurement of the major cost components of highway construction. Despite a period of deflation during the past 2 years, and a 340 percent increase in current dollar disbursements during the past 30 years, capital outlays in 1982 are expected to be worth less in constant dollars than they have been in any year since the pre-Interstate era of the early 1950's. During the 6-year period 1971-1977, the BPI rose 64 percent; but from 1977 to 1980 it experienced almost the same increase (63 percent) in half the period of time. Since then, the relative value of all highway disbursements has benefited from decreases in the index in 1981 and in 1982. The first quarter for 1982 was 11 percent less than the average for 1980.

Capital Disbursements by Improvement Type and Functional Classification

Another way of looking at the overall highway capital disbursements is by examining the types of improvements being undertaken on each of the functional systems. Information presented in the January 1981 report "The Status of the Nation's Highways: Conditions and Performance" included estimated **obligations** by functional system based on data reported by various State and local governments. This data was not available for this report, due to recent Federal efforts to reduce data reporting burdens. Consequently, data on 1980 and 1981 capital **disbursements** have been substituted to provide a similar analysis of how and where capital investments are being made. Whereas obligations are permitted to be incurred immediately after apportionment or allocation, the actual disbursement of funds for these projects does not occur until some time later, when repayment is requested by the disbursing highway agency. Thus, many months or years may pass between an obligation and the subsequent disbursement. Therefore, it is possible that there is some duplication between the obligations used in the earlier report and the disbursements in this report. The disbursement data in this report is, at best, only a rough indication of the shifts in capital investments since the previous report.

Table II-3 summarizes disbursements[1/] by Federal and State governments in rural areas by improvement type and functional system. In rural areas, investment in 3R, reconstruction, and new construction activities accounted for most of the capital disbursements (Figure II-7). The principal arterials (other than Interstate) were the biggest recipients of these disbursements (37 percent) (Figure II-8). These investment distributions compare very closely to the obligations for 1976-1978 reported in the 1981 study. However, a substantially larger share of total expenditures went to the Interstate System for each type of improvement than in the previous reporting period. This increase was offset by decreases in the shares of expenditures that went to the minor arterials and collectors and may explain why the overall condition of those systems has declined in recent years.

1/ Tables II-3, II-4, and II-5 do not include disbursements for Interstate completion purposes. Such disbursements are included in Tables II-6, II-7, and II-8.

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Tables II-4 and II-5 summarize disbursements in urbanized and small urban areas, respectively, by improvement type and functional system. Figure II-9 provides a comparison of recent urban disbursements by improvement type, with a similar breakdown of obligations from the previous report. No significant shifts in the share of disbursements for any type of improvement is apparent in either urbanized or small urban areas.However, as in rural areas, capital investment on major highways, especially on the Interstate System, increased significantly (Figure II-10), while declining on the minor arterials and collectors.

Interstate Completion

Again, it should be noted that Tables II-3, II-4, and II-5 did not include outlays for Interstate completion. Estimates of the cost-to-complete the Interstate System and obligations for that purpose are reported separately to Congress. However, Tables II-6, II-7, and II-8 do include disbursements for Interstate completion purposes and reflect the degree of importance that is being given to completion and to 4R activities. In urbanized areas, more than half (53 percent) of all Federal and State highway capital disbursements went to the Interstate System, and the figure was nearly 40 percent for the rural, small urban, and urbanized areas combined.

Highway Debt Service

Nationally, interest and redemption payments on highway debt (debt service) rarely exceed 10 percent of total highway disbursements. During the 1970's, debt service averaged between 9 and 10 percent of total disbursements and lately has dropped slightly relative to all other highway costs. Even so, some States are hard pressed to meet their debt obligations and maintain their deteriorating highway systems.

Borrowing for highway investment tends to be a more common practice in Eastern States. Retirement of the debt and interest payments command a high priority claim on current user revenues and often absorb a sizable portion of the user revenues. For the 40 or more States servicing debt in recent years, the debt service has absorbed about 15 percent of net-user revenues. However, for eight States, one-fourth or more of the net-user revenue was absorbed by debt service, and three States used 50 percent of net user revenues for debt service at least once in the recent past.

Clearly, the debt burden has become a serious problem in some States, increasing the capital shortage by claiming increasing amounts and proportions of the available revenue for noncapital uses.

HIGHWAY REVENUES

Total dollars collected for highway purposes by all units of government in 1982 are expected to be 65 percent higher than the total collected 10 years earlier. In constant dollars, however, the 1982 revenues will actually be worth 28 percent (or almost $5 billion) less than the amount available for highway use in 1972. Figure II-11 summarizes the growth in total revenues available to meet highway needs since 1960 and the effect of inflation upon the value of these revenues. Between 1960 and 1971, total dollars collected for highway purposes increased an average of 7 percent per year, or

slightly ahead of the pace of inflation in the highway industry. During the following 11-year period (1971-1982) the earlier gains in the buying power of the highway dollar were more than offset. Highway revenues grew at only a 4.8 percent annual rate, while highway costs increased an average of 8.3 percent annually, despite a downturn of more than 10 percent in the BPI which began in early 1980, and continued through the first quarter of 1982. Consequently, total highway revenues collected in 1982 could not buy as much as they could at any time during the 1960's and 1970's.

Table II-9 provides a breakdown of highway dollars collected by each governmental jurisdiction and the share that each jurisdiction's collections represent of total revenues. In 1981, Federal revenues fell below 25 percent of the total highway revenue picture for the first time since the Federal tax on motor fuels was increased in 1959. State revenues have picked up this slack during the past few years.

Background

The Federal and State governments together collect more than three-fourths of all highway receipts. They have historically relied upon road-user taxes and similar charges, including motor-fuel taxes, vehicle registration fees, and certain other special-use taxes and tolls to finance highway needs. Road-user taxes were first levied in 1919, and by 1920 all States were applying some type of user tax. The Federal Government adopted the practice in the 1930's. The Federal-Aid Highway Act of 1956 and the accompanying Revenue Act established the Highway Trust Fund, which reaffirmed the concept of a user-supported highway system. Increases in driver age population and per capita travel helped these user receipts to keep pace with inflation and highway needs. However, the oil embargo of 1973 and subsequent increases in the price of petroleum inspired a more fuel-efficient motor vehicle fleet and slowed the flow of highway-user revenues. The effect of this loss of revenue varied among the various State and local governments, but it had a major impact on the Federal highway program, where there had not been a significant increase in any Federal-user taxes in over 20 years (prior to the pasage of the 1982 Act).

This trend is illustrated in Figure II-12, which provides a breakdown of the sources of Federal highway revenues and shows how the growth of user fees has tapered off in recent years. Increasing amounts of funds are being supplied from the general fund due to the expanded use of Department of Housing and Urban Development block grants, Federal revenue sharing, Interstate substitution projects, economic development funds, and other such funding for highway purposes. Despite this increase of nonuser funding, Federal revenues have grown very little in the past 4 years.

Total highway-user revenues have continued to increase annually at the State level (Figure II-13). However, like the Federal Government, the States are appropriating general funds for highway improvements in addition to shifting the funding of noncapital functions, such as law enforcement and safety activities, to general funds. The sum of these changes tends to reduce the user share of total State highway receipts just as it did at the Federal level.

Local governments rely much less on direct user charges than do the States or Federal Government (Figure II-14), and, the use of non-user revenues has been increasing rapidly. In 1982, user receipts accounted for only 18 percent of all highway revenues collected by local agencies, down from approximately 25 percent 5 years earlier. It should be noted that local jurisdictions normally finance almost all of the local roads (land

access roads) that provide mobility and service only within a local area. In addition the local revenue figures did not include any highway-user fees collected by the States that are eventually shared with the local governments.

User receipts as a percent of total highway revenues collected by all levels of government (Table II-10) amounted to 67 percent in 1981 and 1982. In comparison, during the 1960's and early 1970's, these receipts accounted for more than 80 percent of total highway revenues.

In addition, a significant amount of user fees expended for nonhighway purposes are not included in this data, and thus, the percentages in Table II-10, and Figures II-12, II-13, and II-14 are somewhat understated. In 1980, for example, $2.4 billion in State and local highway-user revenues were expended for nonhighway purposes. If these revenues were replaced by an identical amount of general funds, user fees as a percentage of total highway revenues in 1980 would increase from 66.4 percent (Table II-10) to 72.5 percent.

Intergovernmental Transfers

Nearly all Federal revenues, including Highway Trust Fund receipts, are distributed as grants-in-aid to State and local governments. Similarly, States transfer about 25 percent of their user revenues to local governments. County and municipal governments transfer only minor amounts of user and nonuser fees. Table II-11 provides an indication of the extent to which the various levels of government rely on intergovernmental transfer as income for their respective highway programs. In 1980, for example, net intergovernmental payments to the States totaled nearly $6 billion, equivalent to 30.6 percent of the total.

MANAGEMENT OF FUTURE HIGHWAY REVENUES

State and local governments concerned about the decline in constant dollar investment for highway purposes and the subsequent effect it has had on highway conditions are responding in different ways.

One of the most obvious and often used solutions to the highway revenue shortage, which has been put into use in the last few years, is to raise user taxes and special fees. During the period from January 1, 1980, to September 30, 1982, 29 States enacted legislation increasing their motor-fuel tax rates. Of these, nine States have implemented variable or ad valorem tax mechanisms that tie the tax rate to the price of motor fuel or other indices. Many States are analyzing their highway-user tax structures to improve their effectiveness and equity.

State and local governments have taken other steps to help cope with the current funding constraints on the highway program. Highway management functions are being reviewed and improved in order to help alleviate highway revenue shortfalls and meet the current backlog of needs. Most States are improving their long-term highway management strategies, including developing ways to improve their revenue forecasting and allocation of funds. Short-range programs aimed at improving reporting and evaluation procedures, which focus on the agency's actual accomplishments and goals, are also getting much attention.

A third response to the current highway revenue shortfall has been a reduction in service. This includes such measures as road and bridge abandonment, reduction of

highway standards and services, and deferral of reconstruction and maintenance work. As will be discussed later in this report, such practices often result in higher long-term costs but in many cases they have appeared to be the only options available.

While the need for future highway revenues will be substantially affected by the efficiency and effectiveness of the highway management practices of today, it should be remembered that forces beyond the control of the highway managers will continue to make their job more difficult. The cost and availability of oil may again have a dramatic impact on highway costs, travel, and revenues. And, if shifts in tax bases and population away from the north and east and toward the south and west continue, they can be expected to influence highway revenues and needs. States that relied heavily on bonds during the 1960's and 1970's to finance their highway programs may be affected by decreased revenue funding bases and/or increased interest rates and unexpected inflation levels.

Finally, forecasts of future highway revenue sources must consider that a movement has been underway at the State and local level (Proposition 13, et al) since the mid-1970's that has led to statutes and constitutional amendments that limit the government's ability to tax and/or spend. Altogether, 16 States have passed such laws since 1975. This so-called "tax revolt" has begun to reemphasize a desire to control the growth of disbursements for public programs. Its possible future impact on highway revenues and disbursements cannot be accurately predicted, but should be recognized.

Table II-1[1/]

Total Disbursements[2/] for Highways by all Levels of Government
(In millions of dollars)

Year	Federal		State		Local		Total	
	Amount	Percent Change[3/]	Amount	Percent Change[3/]	Amount	Percent Change[3/]	Amount	Percent Change
1965	4,137	-3.30	7,065	7.90	2,254	4.40	13,456	3.63
1966	4,610	11.43	7,643	8.18	2,530	12.24	14,783	9.86
1967	4,390	-4.77	8,507	11.30	2,807	10.95	15,704	6.23
1968	4,822	9.84	9,069	6.61	3,021	7.62	16,912	7.69
1969	4,557	-5.50	9,842	8.52	3,205	6.09	17,604	4.09
1970	5,200	14.11	10,970	11.46	3,413	6.49	19,583	11.24
1971	5,658	8.81	11,760	7.20	3,781	10.78	21,199	8.25
1972	5,428	-4.07	12,548	6.70	3,953	4.55	21,929	3.44
1973	5,440	0.22	13,281	5.84	4,067	2.88	22,788	3.92
1974	6,155	13.14	13,696	3.12	4,821	18.54	24,672	8.27
1975	7,224	17.37	14,263	4.14	5,720	18.65	27,207	10.27
1976	7,853	8.71	13,964	-2.10	5,921	3.51	27,738	1.95
1977	7,621	-2.96	14,365	2.55	6,198	4.68	28,184	1.61
1978	8,397	10.18	16,248	13.11	7,196	16.10	31,841	12.98
1979	10,200	21.47	17,870	9.98	7,623	5.93	35,693	12.10
1980	12,043	18.07	18,960	6.10	9,020	18.33	40,023	12.13
1981	10,746	-10.77	19,182	1.18	8,933[4/]	-0.96	38,861	-2.90
1982[5/]	10,542	-1.90	19,975	4.13	8,369	-6.31	38,886	0.06

1/ Highway Statistics, HF-10, HF-12 (unpublished in-house tabulations).

2/ Excludes debt retirement, but includes interest on debt.

3/ From previous year.

4/ Preliminary

5/ Forecast

Table II-2
Disbursements for Highways by Functions,[1/] [2/]
All Units of Governments
(In millions of dollars)

	Capital Outlay	Maintenance and Operation	Administration, etc.	Highway Patrol and Safety	Debt Service	Total
1970	11,575	4,720	1,275	1,303	1,962	20,835
1971	12,306	5,114	1,436	1,503	2,121	22,480
1972	12,275	5,443	1,600	1,671	2,220	23.199
1973	12,165	5,949	1,735	1,891	2,446	24,193
1974	13,102	6,573	1,857	2,061	2,524	26,117
1975	14,398	7,286	1,981	2,431	2,621	28,699
1976	13,927	7,735	2,209	2,633	2,801	29,305
1977	13,079	8,612	2,370	2,842	2,929	29,832
1978	14,938	9,785	2,590	3,160	2,961	33,434
1979	17,612	10,571	2,726	3,359	3,176	37,444
1980	20,300	11,405	3,023	3,824	3,176	41,728
1981[3]	18,786	11,713	3,246	3,979	3,402	41,126
1982[4/]	18,127	11,465	3,424	4,148	3,569	40,733

1/ Highway Statistics, HF-10, HF-12 (unpublished in-house tabulation).

2/ Includes debt retirement and interest on debt.

3/ Preliminary

4/ Forecast

Table II-3
Share of Rural Disbursements by Federal and State Governments
by Improvement Type and Functional Classification 1980-1981 1/

Type of Improvement	Functional Systems: Interstate	Other Principal Arterials	Minor Arterial	Major Collector	Minor Collector	Total
New Construction						
% by Functional System	10.5	62.2	12.9	12.3	2.1	100.0
% of All Improvements	10.0	34.7	13.9	12.4	15.3	20.4
% of Total Expenditures	2.1	12.7	2.6	2.5	0.4	20.4
Reconstruction						
% by Functional System	23.4	32.4	22.0	20.6	1.6	100.0
% of All Improvements	24.4	19.7	25.9	22.5	12.6	22.3
% of Total Expenditures	5.2	7.2	4.9	4.6	0.3	22.3
Major Widening						
% by Functional System	14.3	65.9	13.5	5.9	0.4	100.0
% of All Improvements	4.0	10.7	4.2	1.7	0.8	5.9
% of Total Expenditures	0.8	3.9	0.8	0.4	0.0	5.9
RRR						
% by Functional System	26.3	24.2	22.3	23.9	3.3	100.0
% of All Improvements	36.7	19.6	35.1	34.9	35.3	29.7
% of Total Expenditures	7.8	7.2	6.6	7.1	1.0	29.7
Bridge						
% by Functional System	12.8	25.4	22.4	34.4	5.0	100.0
% of All Improvements	8.4	9.8	16.7	23.7	25.5	14.1
% of Total Expenditures	1.8	3.6	3.2	4.8	0.7	14.1
Safety and Other						
% by Functional System	46.3	26.5	10.3	13.0	3.9	100.0
% of All Improvements	16.5	5.5	4.2	4.8	10.5	7.6
% of Total Expenditures	3.5	2.0	0.8	1.0	0.3	7.6
Total						
% by Functional System	21.4	36.6	18.9	20.4	2.7	100.0
% of All Improvements	100.0	100.0	100.0	100.0	100.0	100.0
% of Total Expenditures	21.4	36.6	18.9	20.4	2.7	100.0

1/ Percentages do not reflect disbursements for Interstate completion purposes.

Table II-4
Share of Urbanized Disbursements by Federal and State Governments
by Improvement Type and Functional Classification 1980-1981 1/

Type of Improvement	Functional Systems					
	Inter-state	Other Freeways & Expressways	Other Principal Arterials	Minor Arterials	Collectors	Total
New Construction						
% by Functional System	11.8	22.2	51.5	10.0	4.5	100.0
% of All Improvements	8.5	41.8	50.3	16.5	22.1	26.6
% of Total Expenditures	3.1	5.9	13.7	2.7	1.2	26.6
Reconstruction						
% by Functional System	57.1	12.1	10.2	16.7	3.9	100.0
% of All Improvements	35.0	19.6	8.5	23.4	16.2	22.7
% of Total Expenditures	13.0	2.8	2.3	3.8	0.9	22.7
Major Widening						
% by Functional System	53.8	4.0	21.5	15.2	5.5	100.0
% of All Improvements	12.2	2.3	6.7	7.9	8.5	8.4
% of Total Expenditures	4.5	0.3	1.8	1.3	0.5	8.4
RRR						
% by Functional System	39.3	13.2	21.2	16.6	9.7	100.0
% of All Improvements	16.5	14.6	12.2	15.9	27.7	15.6
% of Total Expenditures	6.1	2.1	3.3	2.6	1.5	15.6
Bridge						
% by Functional System	37.8	10.8	21.9	25.6	3.9	100.0
% of All Improvements	17.1	12.8	13.4	16.3	12.1	16.7
% of Total Expenditures	6.3	1.8	3.7	4.3	0.7	16.7
Safety and Other						
% by Functional System	39.7	12.6	24.2	16.2	7.3	100.0
% of All Improvements	10.7	8.9	8.9	10.0	13.4	10.0
% of Total Expenditures	4.3	1.3	2.4	1.6	0.7	10.0
Total						
% by Functional System	37.0	14.1	27.2	16.2	5.5	100.0
% of All Improvements	100.0	100.0	100.0	100.0	100.0	100.0
% of Total Expenditures	37.0	14.1	27.2	16.2	5.5	100.0

1/ Percentages do not reflect disbursements for Interstate completion purposes.

Table II-5
Share of Small Urban Disbursements by Federal and State Governments
by Improvement Type and Functional Classification 1980-1981 1/

Type of Improvement	Functional Systems: Inter-state	Other Freeways & Expressways	Other Principal Arterials	Minor Arterials	Collectors	Total
New Construction						
% by Functional System	0.9	37.9	42.0	11.5	7.7	100.0
% of All Improvements	0.5	51.4	10.8	9.4	13.7	12.3
% of Total Expenditures	0.1	4.7	5.2	1.4	1.0	12.3
Reconstruction						
% by Functional System	30.8	2.2	42.7	17.4	6.9	100.0
% of All Improvements	54.1	8.9	33.1	43.3	36.9	37.1
% of Total Expenditures	11.4	0.8	15.8	6.5	2.6	37.1
Major Widening						
% by Functional System	3.3	6.0	79.5	7.9	3.3	100.0
% of All Improvements	1.3	5.7	14.3	4.5	4.1	8.6
% of Total Expenditures	0.3	0.5	6.9	0.7	0.3	8.6
RRR						
% by Functional System	14.4	7.1	51.7	19.3	7.5	100.0
% of All Improvements	12.3	14.1	19.5	23.3	19.5	18.0
% of Total Expenditures	2.6	1.3	9.3	3.5	1.4	18.0
Bridge						
% by Functional System	20.4	3.1	56.0	13.0	7.5	100.0
% of All Improvements	9.7	3.4	11.8	8.7	10.8	10.0
% of Total Expenditures	2.1	0.3	5.6	1.3	0.8	10.0
Safety and Other						
% by Functional System	33.8	10.8	36.3	11.6	7.5	100.0
% of All Improvements	22.1	16.5	10.5	10.8	15.0	13.9
% of Total Expenditures	4.7	1.5	5.0	1.6	1.0	13.9
Total						
% by Functional System	21.2	9.1	47.8	14.9	7.0	100.0
% of All Improvements	100.0	100.0	100.0	100.0	100.0	100.0
% of Total Expenditures	21.2	9.1	47.8	14.9	7.0	100.0

1/ Percentages do not reflect disbursements for Interstate completion purposes.

Table II-6
Share of Rural Disbursements by Federal and State Governments,
Including Interstate Completion,
by Improvement Type and Functional Classification 1980-1981

Type of Improvement	Functional Systems					
	Inter-state	Other Principal Arterials	Minor Arterial	Major Collector	Minor Collector	Total
New Construction						
% by Functional System	54.2	31.8	6.6	6.3	1.1	100.0
% of All Improvements	53.0	34.7	13.9	12.4	15.3	33.4
% of Total Expenditures	18.1	10.6	2.2	2.1	0.4	33.4
Reconstruction						
% by Functional System	23.4	32.4	22.0	20.6	1.6	100.0
% of All Improvements	12.8	19.7	25.9	22.5	12.6	18.6
% of Total Expenditures	4.4	6.0	4.1	3.8	0.3	18.6
Major Widening						
% by Functional System	14.3	65.9	13.5	5.9	0.4	100.0
% of All Improvements	2.1	10.7	4.2	1.7	0.8	4.9
% of Total Expenditures	0.7	3.3	0.7	0.3	0.0	4.9
RRR						
% by Functional System	26.3	24.2	22.3	23.9	3.3	100.0
% of All Improvements	19.1	19.6	35.1	34.9	35.3	24.9
% of Total Expenditures	6.6	6.0	5.6	5.9	0.8	24.9
Bridge						
% by Functional System	12.8	25.4	22.4	34.4	5.0	100.0
% of All Improvements	4.4	9.8	16.7	23.7	25.5	11.8
% of Total Expenditures	1.5	3.0	2.6	4.0	0.6	11.8
Safety and Other						
% by Functional System	46.3	26.5	10.3	13.0	3.9	100.0
% of All Improvements	8.6	5.5	4.2	4.8	10.5	6.4
% of Total Expenditures	2.9	1.7	0.7	0.8	0.2	6.4
Total						
% by Functional System	34.2	30.6	15.8	17.1	2.3	100.0
% of All Improvements	100.0	100.0	100.0	100.0	100.0	100.0
% of Total Expenditures	34.2	30.6	15.8	17.1	2.3	100.0

Table II-7
Share of Urbanized Disbursements by Federal and State Governments Including Interstate Completion, by Improvement Type and Functional Classification 1980-1981

Type of Improvement	Functional Systems					
	Inter-State	Other Freeways & Expressways	Other Principal Arterials	Minor Arterials	Collectors	Total
New Construction						
% by Functional System	61.3	9.7	22.6	4.4	2.0	100.0
% of All Improvements	52.2	41.8	50.3	16.5	22.1	45.2
% of Total Expenditures	27.7	4.4	10.2	2.0	0.9	45.2
Reconstruction						
% by Functional System	57.1	12.1	10.2	16.7	3.9	100.0
% of All Improvements	18.3	19.6	8.5	23.4	16.2	17.0
% of Total Expenditures	9.7	2.1	1.7	2.8	0.7	17.0
Major Widening						
% by Functional System	53.8	4.0	21.5	15.2	5.5	100.0
% of All Improvements	6.4	2.3	6.7	7.9	8.5	6.3
% of Total Expenditures	3.4	0.2	1.4	1.0	0.3	6.3
RRR						
% by Functional System	39.3	13.2	21.2	16.6	9.7	100.0
% of All Improvements	8.6	14.6	12.2	15.9	27.7	11.6
% of Total Expenditures	4.6	1.5	2.5	1.9	1.1	11.6
Bridge						
% by Functional System	37.8	10.8	21.9	25.6	3.9	100.0
% of All Improvements	8.9	12.9	13.4	26.3	12.1	12.5
% of Total Expenditures	4.7	1.3	2.7	3.2	0.5	12.5
Safety and Other						
% by Functional System	39.7	12.6	24.2	16.2	7.3	100.0
% of All Improvements	5.6	8.9	8.9	10.0	13.4	7.4
% of Total Expenditures	3.0	0.9	1.8	1.2	0.5	7.4
Total						
% by Functional System	53.0	10.5	20.3	12.1	4.1	100.0
% of All Improvements	100.0	100.0	100.0	100.0	100.0	100.0
% of Total Expenditures	53.0	10.5	20.3	12.1	4.1	100.0

Table II-8
Share of Small Urban Disbursements by Federal and State Governments, Including Interstate Completion, by Improvement Type and Functional Classification 1980-1981

Type of Improvement	Functional Systems					
	Inter-state	Other Freeways & Expressways	Other Principal Arterials	Minor Arterials	Collectors	Total
New Construction						
% by Functional System	47.5	20.1	22.2	6.1	4.1	100.0
% of All Improvements	34.4	51.4	10.8	9.4	13.7	20.9
% of Total Expenditures	9.9	4.2	4.7	1.3	0.9	20.9
Reconstruction						
% by Functional System	30.8	2.2	42.7	17.4	6.9	100.0
% of All Improvements	35.7	8.9	33.1	43.3	36.9	33.5
% of Total Expenditures	10.3	0.7	14.3	5.8	2.3	33.5
Major Widening						
% by Functional System	3.3	6.0	79.5	7.9	3.3	100.0
% of All Improvements	0.9	5.7	14.3	4.5	4.1	7.8
% of Total Expenditures	0.3	0.5	6.2	0.6	0.3	7.8
RRR						
% by Functional System	14.4	7.1	51.7	19.3	7.5	100.0
% of All Improvements	8.1	14.1	19.5	23.3	19.5	16.3
% of Total Expenditures	2.3	1.2	8.4	3.1	1.2	16.3
Bridge						
% by Functional System	20.4	3.1	56.0	13.0	7.5	100.0
% of All Improvements	6.4	3.4	11.8	8.7	10.8	9.0
% of Total Expenditures	1.8	0.3	5.1	1.2	0.7	9.0
Safety and Other						
% by Functional System	33.8	10.8	36.3	11.6	7.5	100.0
% of All Improvements	14.6	16.5	10.5	10.8	15.0	12.5
% of Total Expenditures	4.2	1.4	4.5	1.5	0.9	12.5
Total						
% by Functional System	28.9	8.2	43.1	13.5	6.3	100.0
% of All Improvements	100.0	100.0	100.0	100.0	100.0	100.0
% of Total Expenditures	28.9	8.2	43.1	13.5	6.3	100.0

Table II-9
Total Revenue for Highways by Governmental Jurisdiction 1960-1982[1/]
(In millions of dollars)

	Federal		State		Municipal		County		
Year	Receipts	Percent	Receipts	Percent	Receipts	Percent	Receipts	Percent	Total
1960	3,063	26.7	6,055	52.7	1,519	13.2	848	7.4	11,485
1961	3,083	26.0	6,281	53.0	1,542	13.0	945	8.0	11,851
1962	3,364	26.4	6,904	54.1	1,483	11.6	1,001	7.8	12,752
1963	3,733	28.9	6,576	51.0	1,624	12.6	972	7.5	12,905
1964	3,907	28.5	7,192	52.5	1,587	11.6	1,007	7.4	13,693
1965	4,079	28.2	7,623	52.8	1,669	11.6	1,067	7.4	14,438
1966	4,720	28.6	8,723	53.8	1,900	11.5	1,172	7.1	16,515
1967	4,921	28.6	9,004	52.3	2,044	11.9	1,244	7.2	17,213
1968	5,064	27.2	10,036	53.8	2,174	11.7	1,360	7.3	18,634
1969	5,772	28.3	10,941	53.6	2,297	11.2	1,416	6.9	20,426
1970	6,144	28.3	11,737	54.0	2,406	11.1	1,460	6.7	21,747
1971	6,584	27.1	13,359	55.1	2,714	11.2	1,603	6.6	24,260
1972	6,286	25.7	13,551	55.3	2,991	12.2	1,655	6.8	24,483
1973	7,419	27.8	14,288	53.5	3,244	12.1	1,752	6.6	26,703
1974	7,846	28.4	14,238	51.6	3,609	13.1	1,889	6.9	27,582
1975	7,676	26.3	15,105	51.8	4,109	14.1	2,270	7.8	29,160
1976	8,038	26.1	16,126	52.3	4,267	13.8	2,400	7.8	30,831
1977	9,230	27.8	16,700	50.2	4,676	14.1	2,637	7.9	33,234
1978	9,750	27.5	17,766	50.0	5,235	14.7	2,753	7.8	35,504
1979	10,560	27.7	18,507	48.6	5,886	15.5	3,132	8.2	38,085
1980[2/]	10,049	26.0	19,435	50.4	5,928	15.4	3,176	8.2	38,588
1981[3/]	9,684	24.4	20,144	50.9	6,408	16.2	3,359	8.5	39,595
1982[3/]	9,873	24.4	21,002	51.9	6,327	15.6	3,265	8.1	40,467
TOTAL	150,845	----	291,293	----	75,639	----	42,383	----	560,160

1/ Highway Statistics, HF-11 (unpublished in-house tabulation).

2/ Preliminary

3/ Forecast

Table II-10
User Receipts as a Percent
of Total Highway Revenues [1]
Collected by All Levels of Government

1960	83.0
1964	82.3
1968	81.3
1971	81.9
1974	77.5
1977	74.3
1978	71.9
1980	66.4
1981[2]	67.0
1982[3]	67.0

1/ Highway Statistics, HF-11, HF-12 (unpublished in-house tabulations).

2/ Preliminary

3/ Forecast

Table II-11
Intergovernmental Transfers as Percent of Local and State Receipts (1965-1982)[1/]

	State	County	Municipal
1965	30.0	97.0	34.0
1966	29.8	89.9	31.3
1967	25.4	86.3	32.1
1968	25.7	85.7	32.6
1969	19.0	92.7	35.2
1970	20.0	97.3	41.8
1971	20.0	92.7	37.0
1972	16.4	95.3	37.0
1973	11.3	111.0	42.3
1974	15.0	108.6	39.7
1975	20.0	94.6	34.8
1976	20.7	96.0	34.6
1977	16.1	93.4	36.9
1978	17.2	97.2	35.1
1979	23.1	83.8	39.8
1980	30.6	87.2	39.9
1981[2/]	24.8	81.0	37.2
1982[3/]	21.2	83.8	38.0

1/ Highway Statistics, HF-11 (unpublished in-house tabulation).

2/ Preliminary

3/ Forecast

Figure II-1
Distribution of Total Highway Disbursements
1962-1982

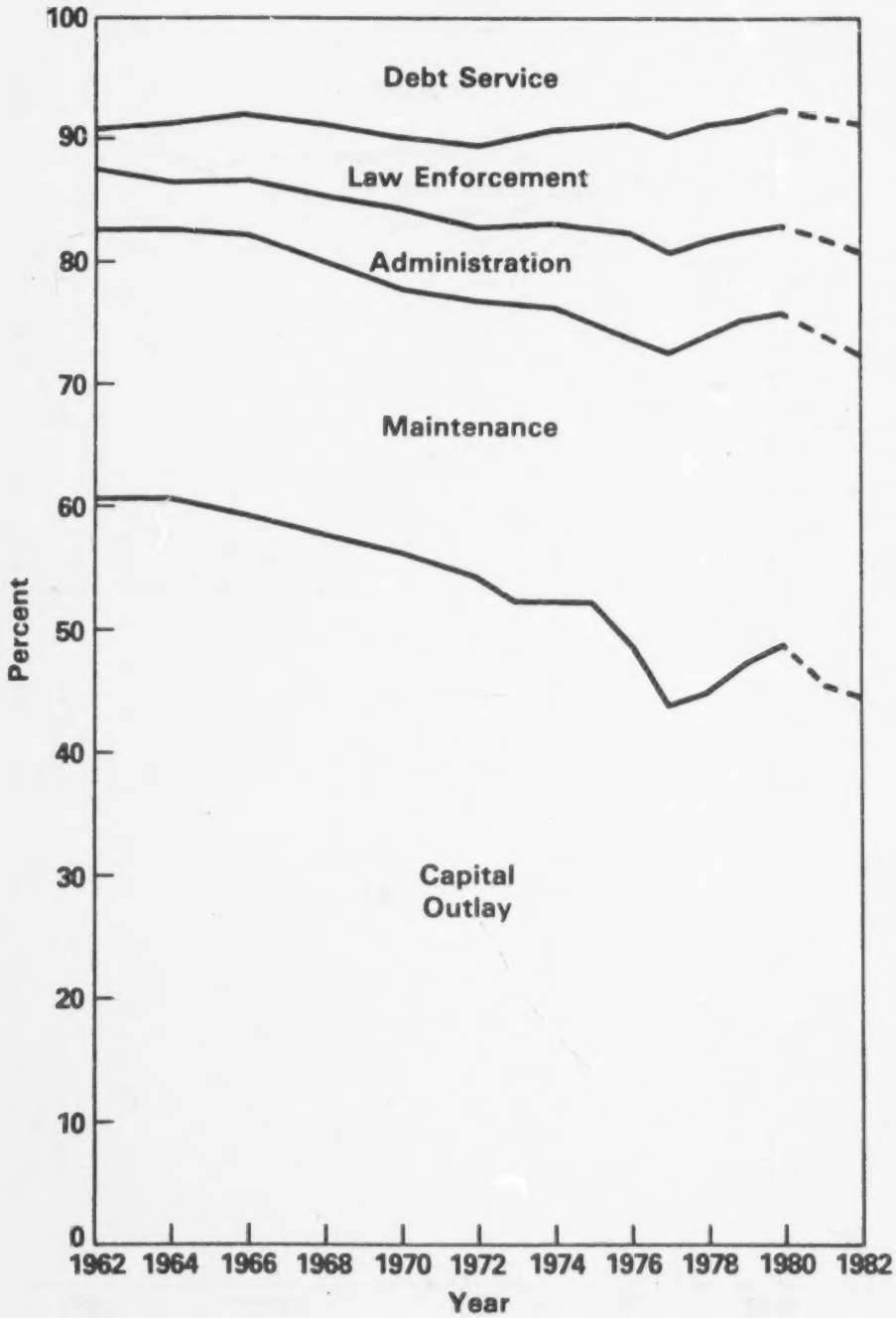

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Figure II-2
Distribution of State Highway Disbursements
1962-1982

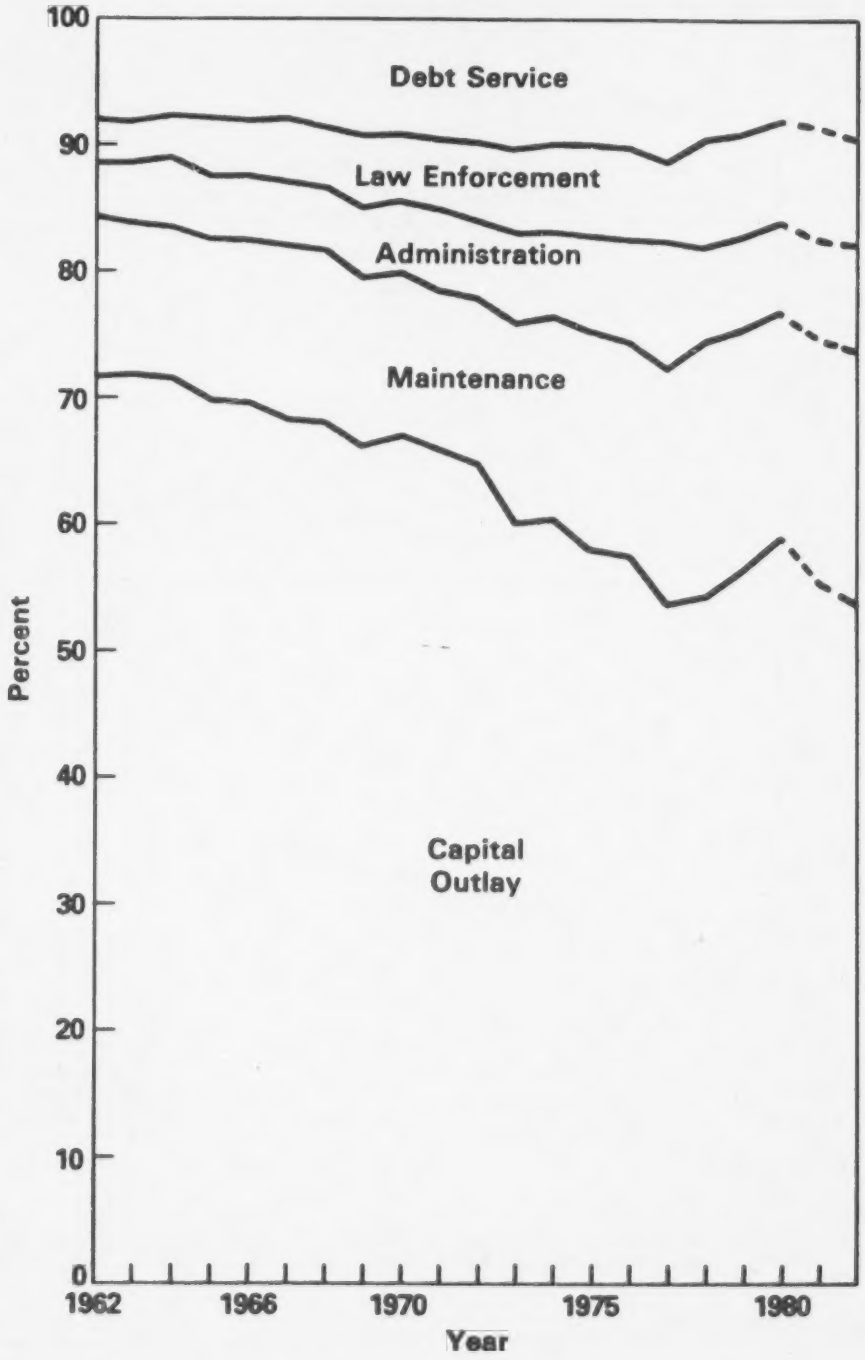

Figure II-3
Distribution of County Highway Disbursements
1962-1982

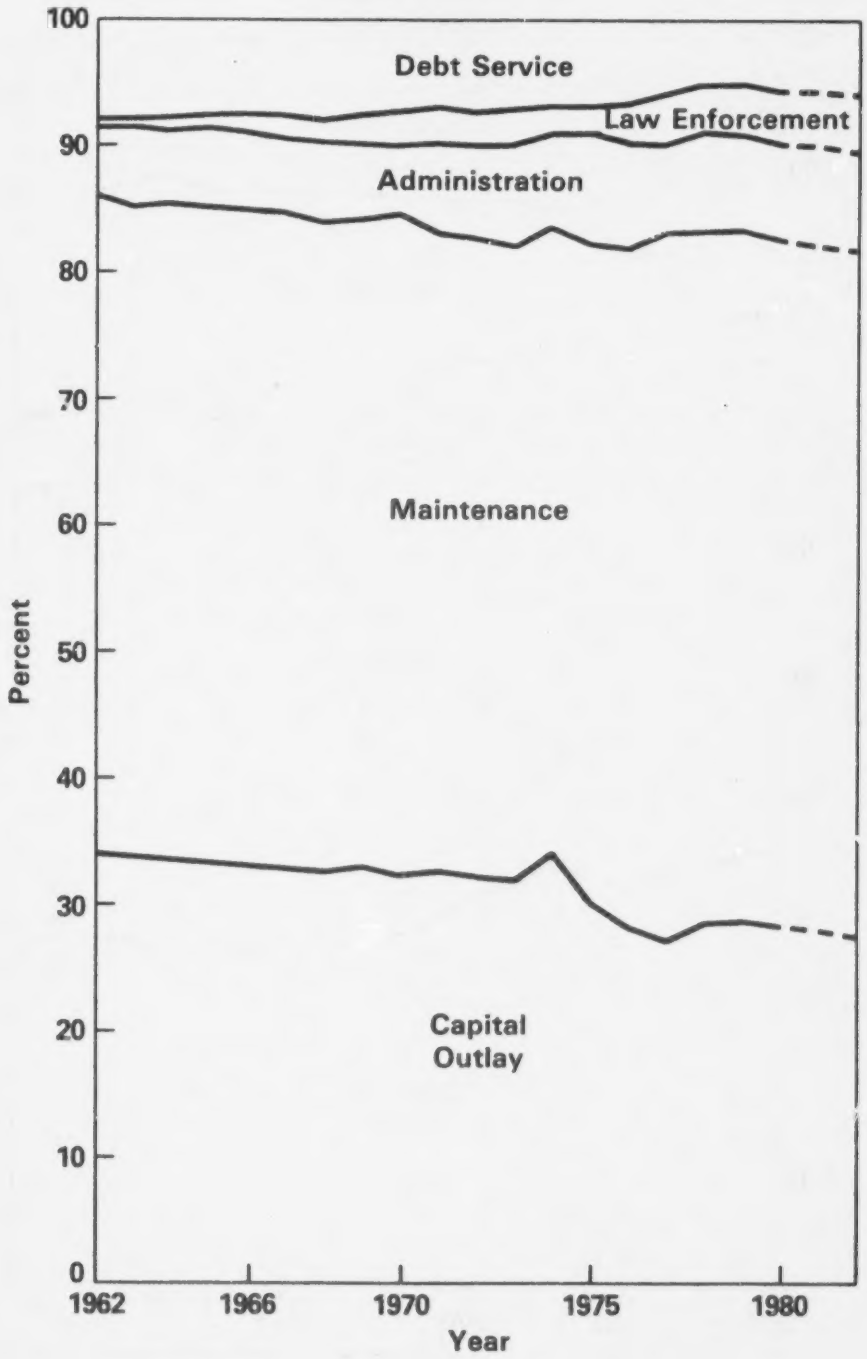

Figure II-4
Distribution of Municipal Highway Disbursements
1962-1982

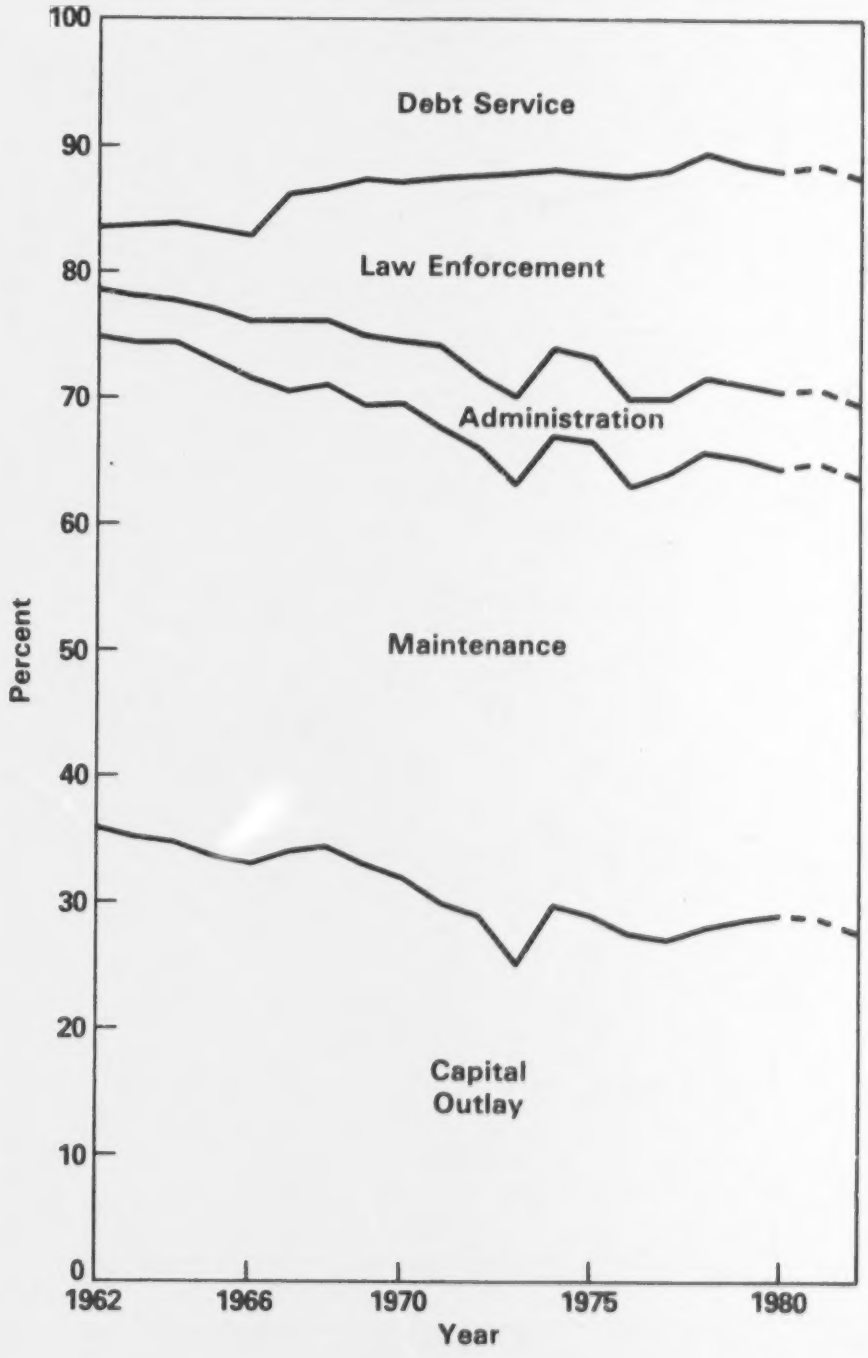

Figure II-5
Total Highway Disbursements and the Capital Program
1960-1982
(In Current Dollars)

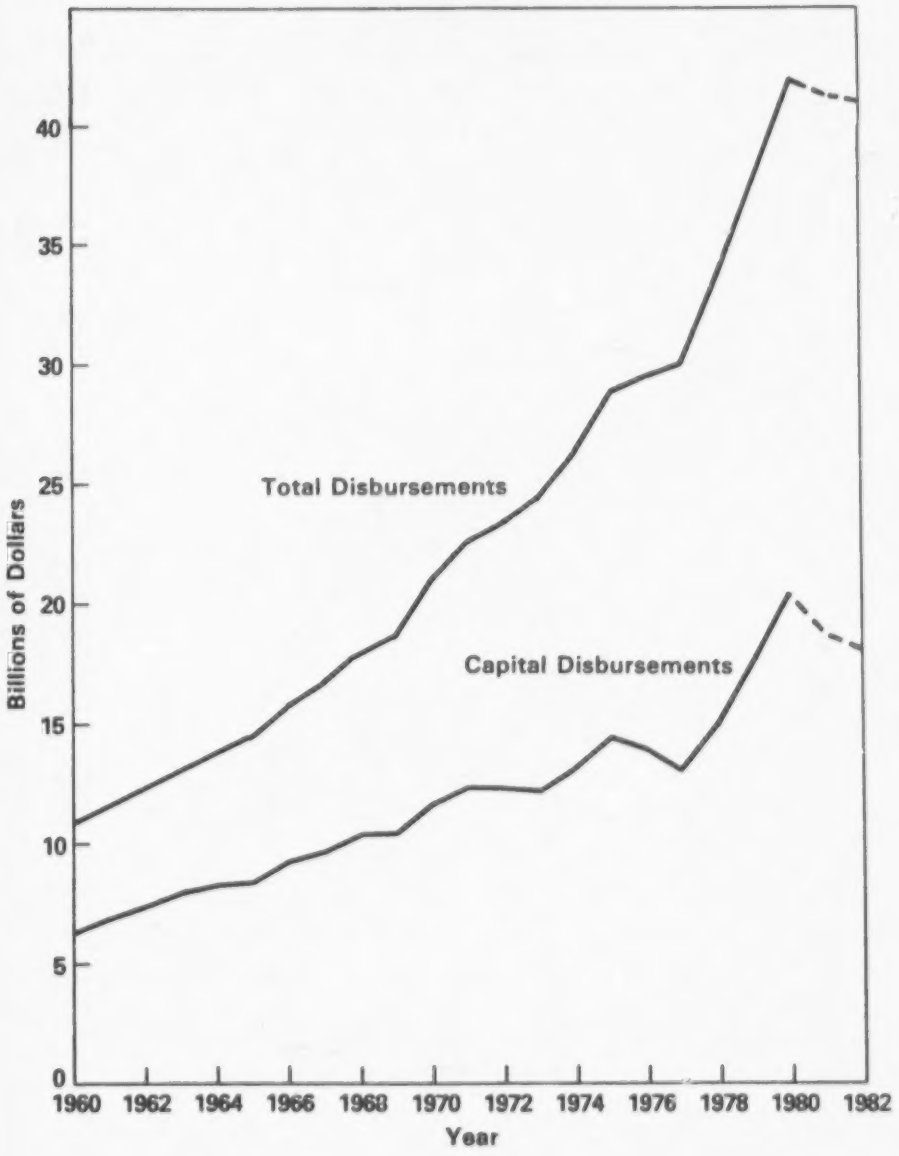

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Figure II-6
Capital Disbursements in Current and Constant Dollars
1954-1982

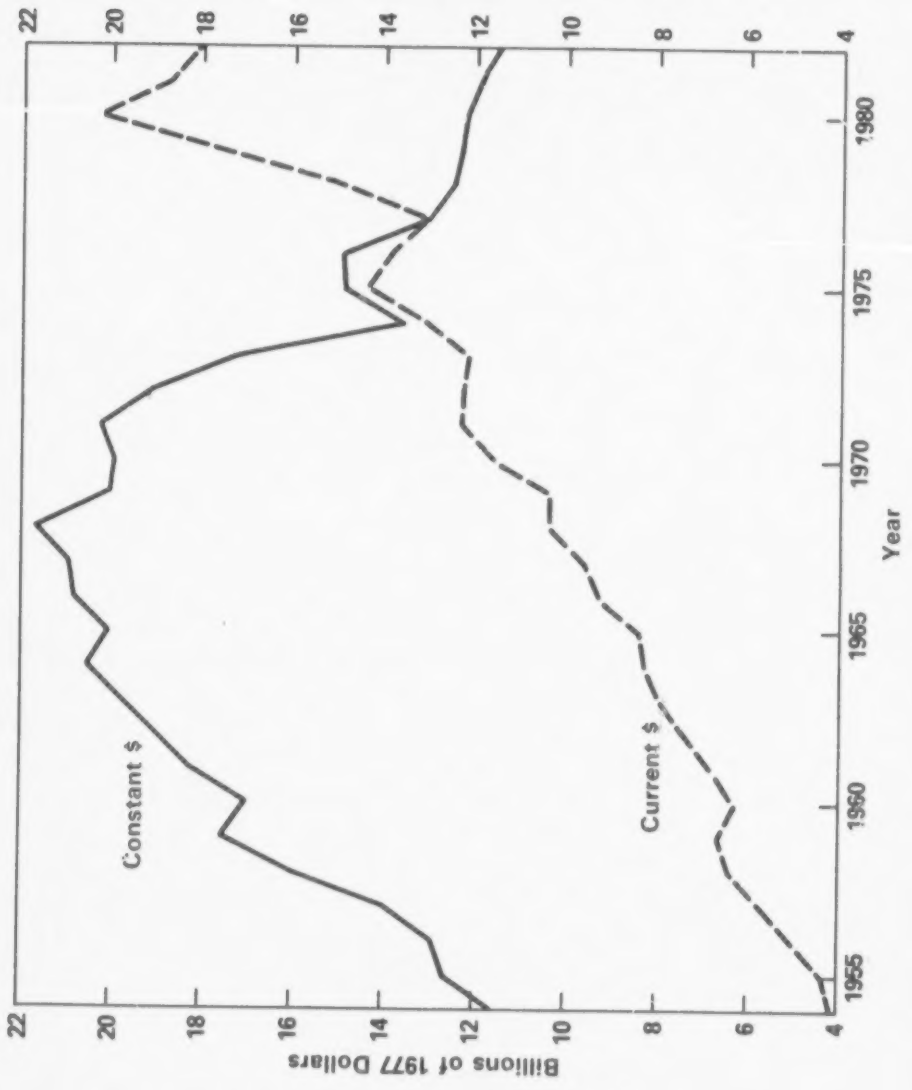


Figure II-7
Rural

Percent Distribution of Obligations (1975-78) and Expenditures (1980-81) by Type of Improvement

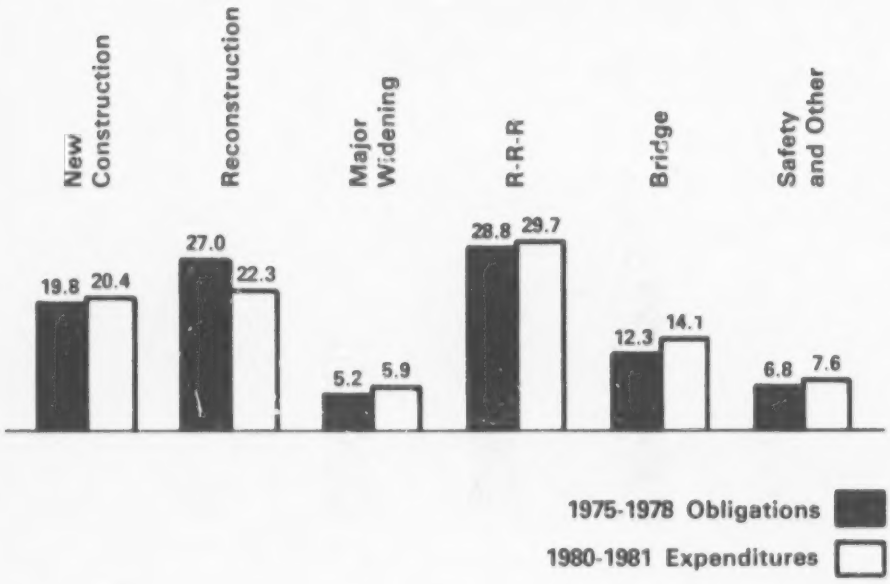


Figure II-8
Rural

Percent Distribution of Obligations (1975-78) and Expenditures (1980-81) by Functional Classification

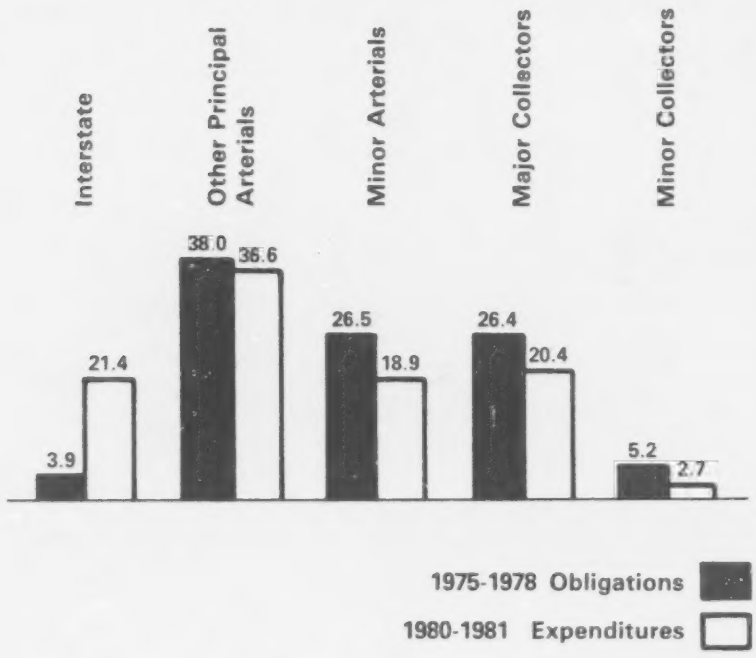


Figure II-9
Urbanized and Small Urban

Percent Distribution of Obligations (1975-78) and Expenditures (1980-81) by Functional Classification

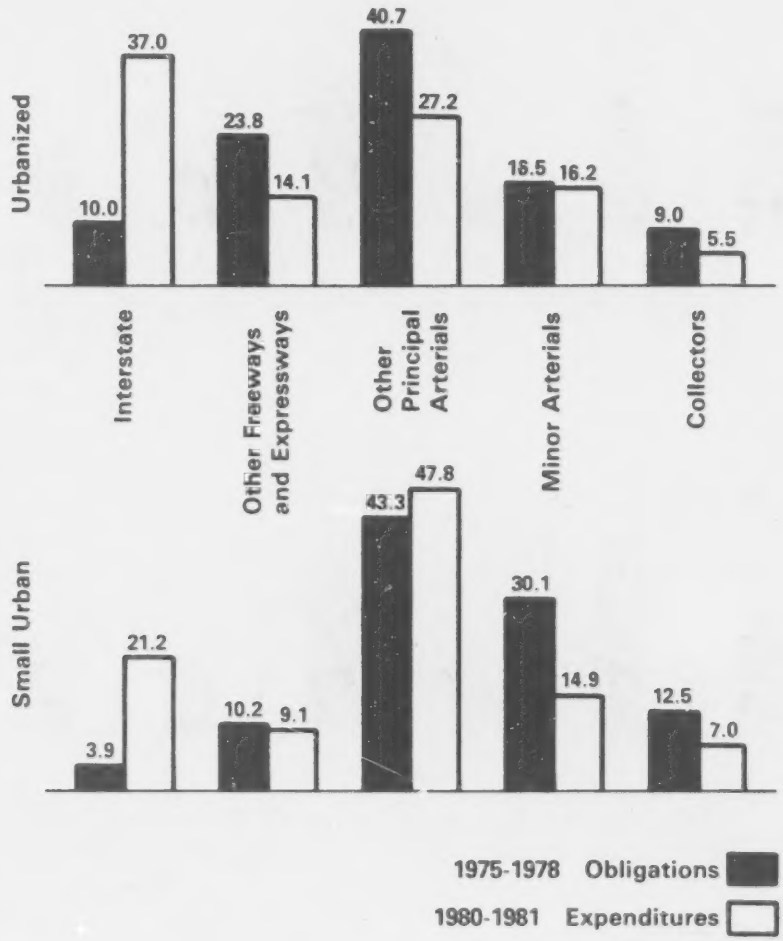


Figure II-10
Urbanized and Small Urban

Percent Distribution of Obligations (1975-78) and Expenditures (1980-81) by Type of Improvement

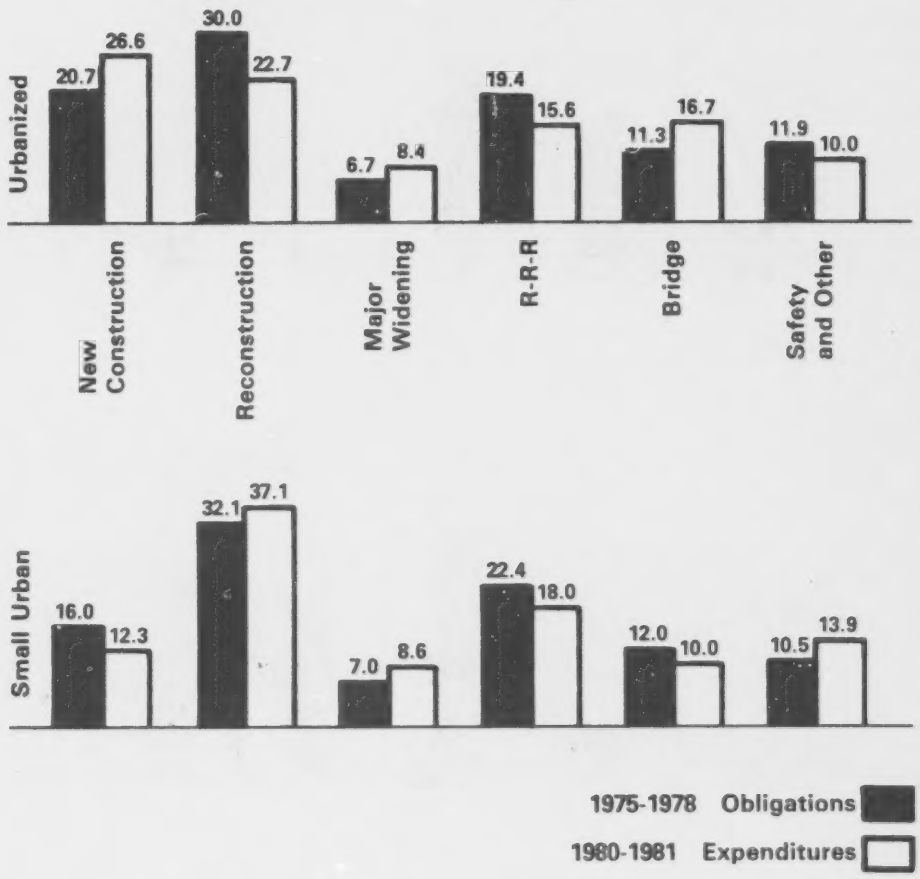


Figure II-11
Growth of Highway Revenues in Current and Constant Dollars for all Units of Government

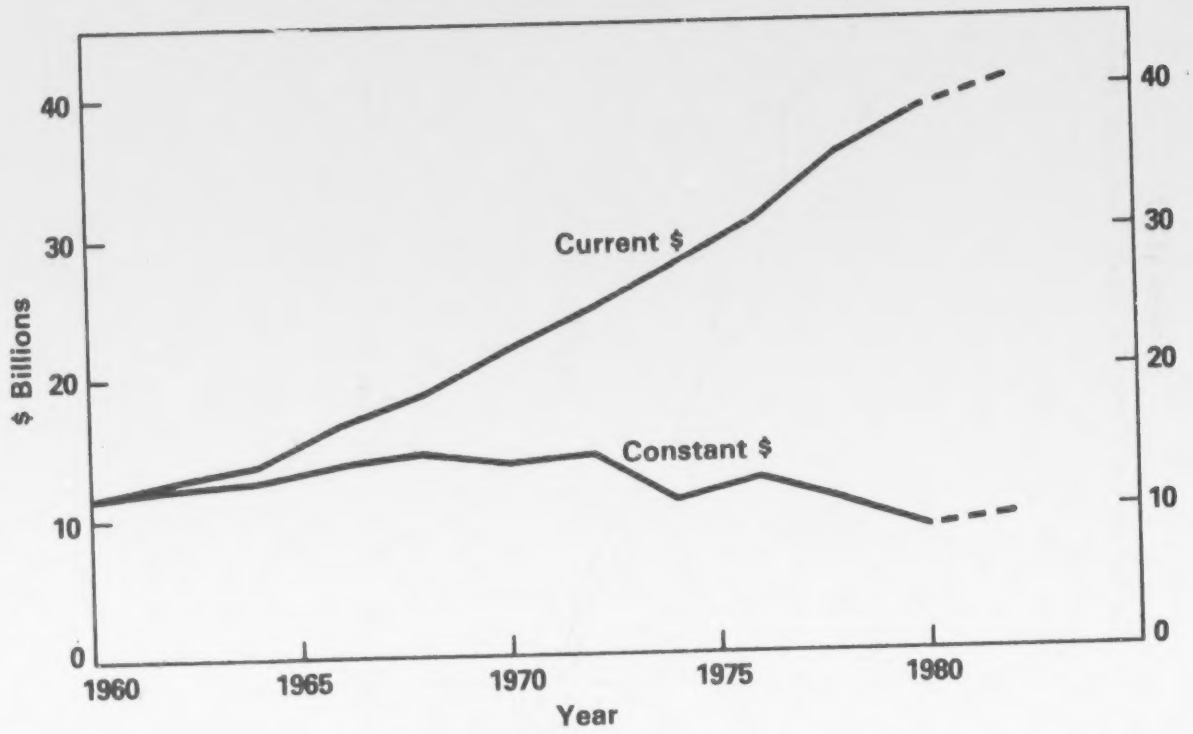


Figure II-12
Sources of Federal Receipts for Highways

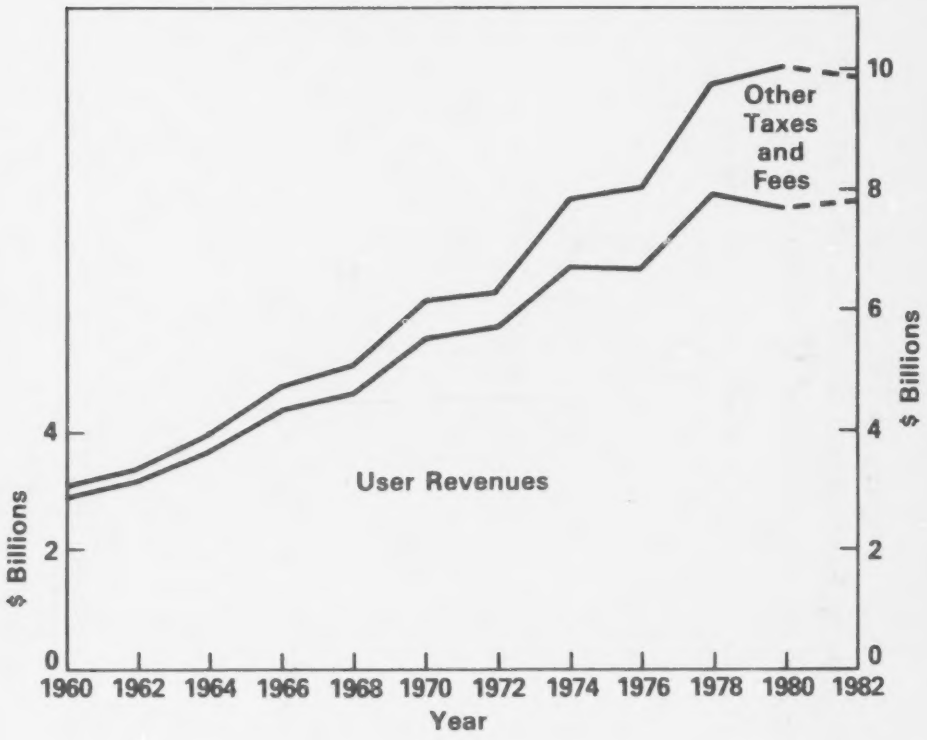


Figure II-13
Sources of State Receipts for Highways

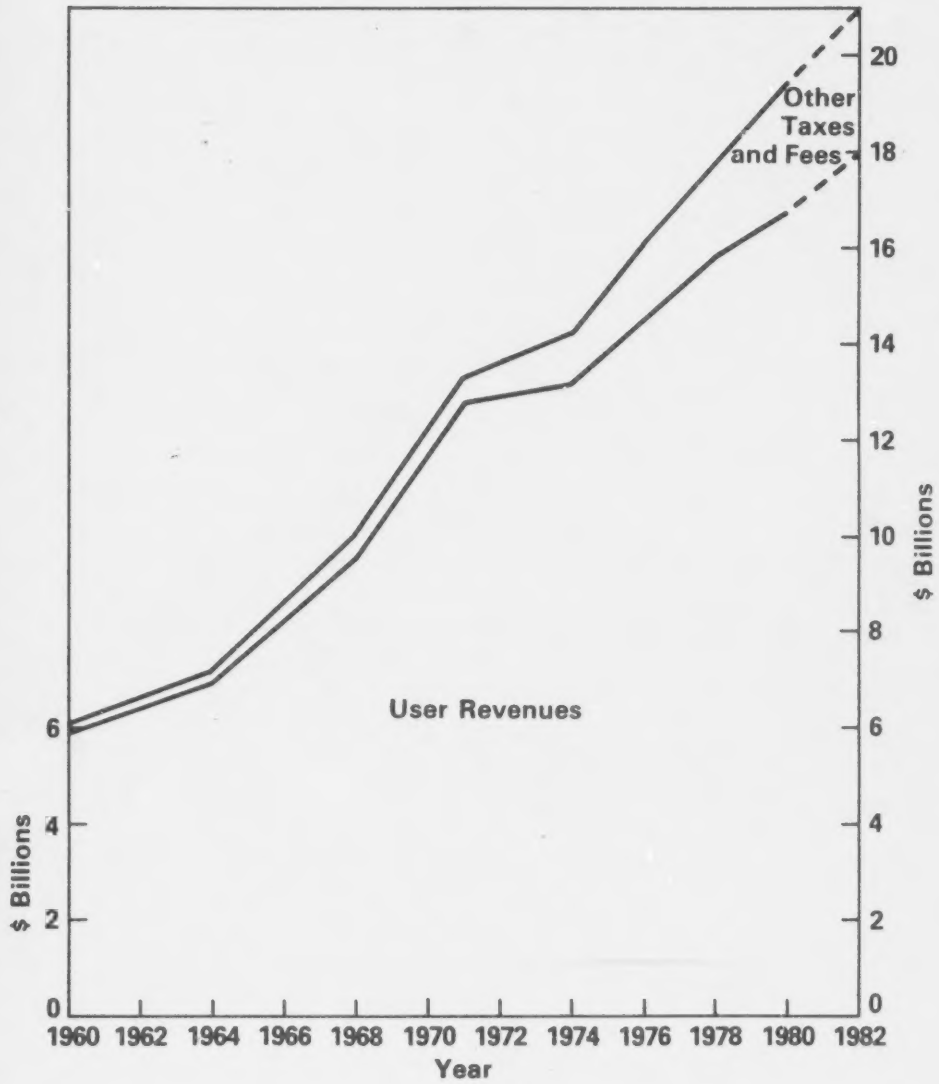
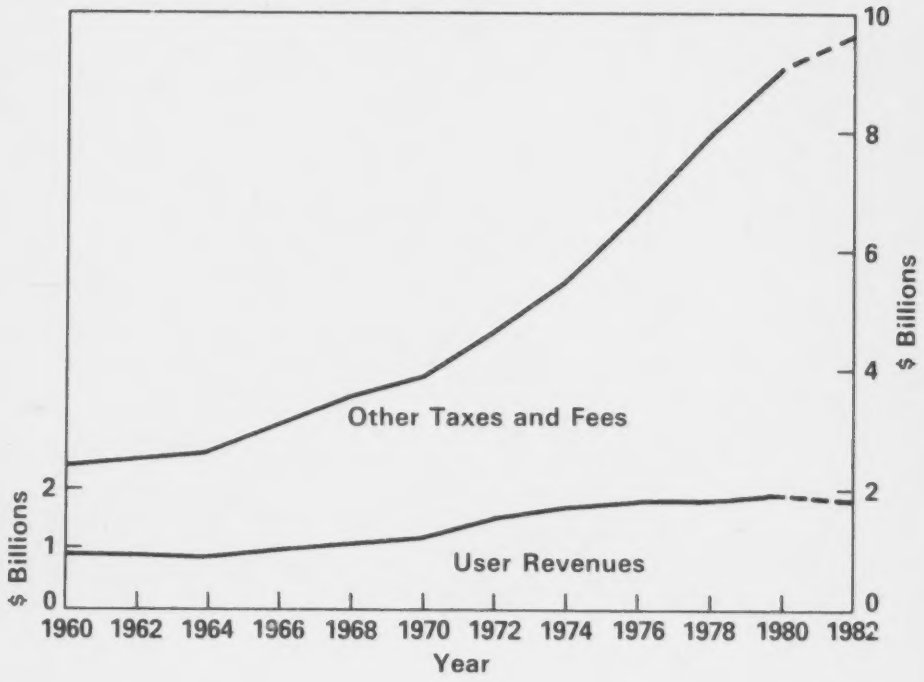


Figure II-14
Sources of Local Receipts for Highways



Chapter III
PHYSICAL CONDITION OF THE NATION'S MAJOR HIGHWAYS

In 1981, over $41 billion was disbursed by local, State and Federal jurisdictions to operate, maintain, and add to the Nation's highway network. Of this amount, $13 billion was for capital improvements on nonlocal roads (Interstate, arterials, and collectors)*. This large investment resulted in thousands of miles of road improvements, varying from capital-intensive new highways to modest resurfacing and local safety improvements. However, while these improvements were taking place, increased travel caused pavement and bridge wear, more congestion, and greater accident potential.

Highway conditions and performance are dynamic characteristics, changing from month to month, and at different rates in different regions. However, definite trends develop as a result of changes in investment, and in taxing policies and priorities. Obviously, highway conditions vary widely among States and even among counties and cities within a State. Such variations result from the nature of the highway program, which reflects local and State priorities and concerns. This chapter will summarize current highway conditions, discuss how the condition of the Nation's highways has changed since 1975 and describe the relationship of the physical elements of the highway to performance characteristics of travel. Highway travel and physical conditions are addressed at the national level.

The chapter focuses on the major functional classes of highways (principal and minor arterials, including Interstate, and major and minor collectors). These account for approximately 30 percent of the Nation's highway mileage and carry 86 percent of the vehicle-miles-of-travel (VMT). The discussion is further stratified into urban and rural categories since the nature of the conditions and the usage of the facilities differs between the two categories.

Information on highway physical conditions was developed from field inventories conducted cooperatively by the FHWA and the States. The FHWA, in cooperation with the States, has developed a data reporting system, The Highway Performance Monitoring System (HPMS), designed to provide periodic assessments of highway conditions and travel throughout the country. Each State developed a random sample of highway sections from its major highway systems. These sample sections were inventoried for such information as geometric design, physical condition, travel, and the level and nature of capital investments on the systems. The 1981 Status of the Nation's Highways was the first report to use HPMS data. At specific intervals of time the States report any changes that have taken place and any capital investment that has been made on the sample sections. The HPMS provides data for program and policy development and review at the Federal level and also supplies data for congressionally mandated studies.

*Highway Statistics, Table HF-10.

HIGHWAY MILEAGE AND TRAVEL

Functional System Mileage

Public road mileage in the United States in 1981 was 3,852,697 miles (see Table III-1). Nearly 70 percent of this mileage is functionally classified as local roads, which primarily provide direct access to homes, agriculture, mining, industrial sites, etc., (see Chapter I for definitions of highway functional systems). Eighty-four percent of all public road mileage is in rural areas. Of the 1,003,364 miles of nonlocal rural roads, 26 percent are arterials; the remainder are collectors. In urban areas, 127,086 miles of nonlocal streets are functionally classified as arterials and 69,109 miles are collectors.

Highway Travel on Functional Systems

Total highway travel on public roads in 1981 was 1.55 trillion VMT (see Table III-1). Forty-four percent of the travel occurred in rural areas and 56 percent occurred in small urban and urbanized areas. The vast majority of the total travel, 86 percent, took place on the functional systems. The remaining 14 percent occurred on local roads.

The Interstate carried 20 percent of all travel on 1 percent of the mileage. The entire rural arterial system, including the Interstate, accounted for 60 percent of all rural travel on 8 percent of the rural mileage. Urban arterials (including Interstate mileage) carried 76 percent of all urban travel and 42 percent of all highway travel on 3.3 percent of the Nation's highway mileage.

Federal-aid (F-A) System Mileage

Table III-2 contains Federal-aid system mileage information. Total existing mileage on all Federal-aid systems in 1981 (see Chapter I) was 828,526 miles, or 22 percent of all public road miles and 69 percent of all non-local road mileage in the United States. Eighty percent of the F-A mileage was in rural areas, closely paralleling the rural-urban distribution of all public road mileage in the country. Of the 263,440 miles of rural arterials (including Interstate), 260,316 miles, or 99 percent, were either on the F-A primary or the Interstate. The F-A secondary system in 1981 included 400,823 miles, or 91 percent of the 440,409 miles of the rural major collectors and 54 percent of all rural collectors.

The Federal-aid primary system consists of rural principal arterials, rural minor arterials, and their urban extensions. Excluding Interstate mileage, which is a subset of the primary system, 89 percent of the 255,988-mile Federal-aid primary system is in rural areas. Urban extensions account for the remaining 11 percent. The system includes nearly all rural arterials (98.6 percent), and 79 percent of urban freeways and expressways. Nearly half (49.2 percent) of other principal arterials in urban areas are on the primary, but only 2 percent of minor arterials are on the system.

Most of the remaining urban arterials are on the Federal-aid urban system which also includes 78 percent of all urban collectors. In sum, 90 percent of all urban expressways and arterials are on the Interstate, primary, or urban systems; much of the remaining 10 percent is toll mileage.

Federal-Aid System Travel

Table III-3 contains Federal-aid system travel information. Total travel on all Federal-aid systems in 1981 equaled 1.23 trillion VMT or 80 percent of all public highway travel. Total travel in 1981 was 1.55 trillion VMT (see Table III-1). Of this total, 44 percent took place on rural F-A system mileage and 56 percent on urban F-A highway systems.

The primary system, excluding the Interstate, carried 29.5 percent of total highway travel in 1981. With the Interstate included, this percentage increased to 49.2 percent. The F-A secondary system carried 142.5 billion VMT, or 9.2 percent of total highway travel, and the FAUS accounted for 327.3 billion VMT (21.1 percent) in 1981. Thirty-eight percent of all urban highway travel occurred on the FAUS.

Highway System Usage

In total, F-A highway systems carried 80 percent of all travel on 22 percent of the public road mileage. In 1981, the Interstate carried 20 percent of all highway travel on 1 percent of the public highway mileage and 9,300 and 2,814 average daily traffic (ADT) per lane-mile on urban and rural routes, respectively. By contrast, local roads carried 14 percent of total travel on 69 percent of the Nation's mileage. The F-A primary system, excluding the Interstate, carried 30 percent of all highway travel on 7 percent of the total road miles. When the Interstate is included, the primary system accounted for nearly half of all highway travel on only 8 percent of the Nation's highways and freeways. The FAUS carried 44 percent of urban travel on 7 percent of the urban streets and freeways. The F-A secondary system accounted for 24 percent of the rural travel on 12 percent of the Nation's rural roads.

Changes in Highway Mileage and Travel (1975-1981)

Table III-4 indicates the change in public road mileage from 1975 through 1981. Growth in rural mileage resulted almost entirely from additions to the local road system and to the Interstate, (89,382 miles and 3,021 miles, respectively). The loss of 3,747 minor arterial miles was due to reclassification in functional class and some shift from rural to urban classification in new suburban areas following the 1980 Federal Census. The increase in major collector mileage was due primarily to reclassification from minor collectors.

In urban areas, the local road system contributed 37,924 new miles (85 percent) of the total urban area highway growth. In general, urban highway mileage grew, in part, as a result of new Interstate, new local road mileage, and the conversion of rural collectors and arterials into suburban streets. Excluding Interstate and local street additions, only 4,100 additional miles were added to the public road network during the period.

Travel Growth (1975 - 1981)

Travel grew at an average annual rate of 2 percent during the period, increasing from 1.33 trillion VMT to 1.55 trillion VMT (see Table III-5). Interstate travel increased 24 percent to 305 billion VMT, and travel on all other arterial routes grew by 11.5 percent to 757 billion VMT during the same period. In general, highway travel increased on all functional systems, with urban routes increasing their share of total travel slightly, from 55 percent in 1975 to 56 percent in 1981.

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PHYSICAL AND OPERATING CONDITIONS OF THE SYSTEMS

Source and Purpose of Information

The States report on some 45 physical and operating conditions through the HPMS. The most recent data available from the States were used for this report. Table III-6 lists the year of the data used for each State, all of which is referred to as "current" data in this report.

The purpose of the information is to determine the condition of a highway system by measuring a variety of physical and operating characteristics, some of which are relatively fixed, e.g., lane width and alignment, and some of which are dynamic, e.g., pavement condition. Conditions can be indicated by measuring any single characteristic or combination of these characteristics. Changes in condition then can be indicated by comparing these measurements over time.

Data reported by the States have been organized into three broad categories: "condition," "service," and "safety." Condition primarily reflects pavement condition and pavement type. Service generally combines peak-period volume-to-capacity ratios, as a measure of congestion, and operating speed. Safety combines horizontal and vertical alignment, lane width, shoulder width and shoulder type.

Two highway conditions that change rapidly over time are pavement condition and congestion. The investment required to correct either of these deficiencies varies considerably. Many miles of deteriorated pavement can be replaced for the investment needed to add a few miles of additional highway traffic lanes. If sufficient funding is not available to eliminate both congestion and deteriorated pavement, obviously some deterioration will occur either to the pavement or to traffic operations.

To measure the net change in these two conditions combined, a Deterioration Index (DI) has been computed that weights both pavement condition and volume/capacity ratios together. The results of this computation are presented in Tables III-7 and III-8. It is difficult to assess the significance of the point change in the DI over time because a reading that indicates good performance could be in the 80 range and a very deteriorated condition could be as high as 60. Therefore, the DI should be used only as an indication of negative or positive trends.

Summary of Conditions

The DI indicates that all highway systems, as measured by a combination of peak-period congestion and pavement conditions, have deteriorated since 1975. For most of the functional systems, this is true for both 1978 and currently when compared to conditions in 1975. Only the urban Interstate and collector systems showed improvement since 1978, where the DI was weighted on a mileage basis. When weighted by travel, however, all systems have declined since 1975 and 1978. The difference in the DI between mileage and travel reflects the influence that congestion has on overall conditions.

The remainder of this chapter addresses pavement condition, congestion, and fatality rates as individual indicators of physical conditions, operating conditions, and safety. Data supplied by the State highway agencies show that trends vary greatly among the various functional systems, for the different time periods, for each of the indicators. It

should be remembered, therefore, that highway conditions and, ultimately, highway performance cannot be measured by any one condition, but is reflected through a composite group of conditions that the traveling public perceives as changing over time.

Pavement Condition

Highway pavement condition is classified by the Present Serviceability Rating (PSR), which varies from a high of 5.0 for new or nearly new pavement to 0.0 for completely deteriorated pavement. Figure III-1 provides a qualitative description of the PSR components. Figure III-2 graphically depicts the same information.

As indicated in Figure III-1, a PSR of 2.0 (2.5 PSR for the Interstate System) marks the point between pavement in fair condition and pavement needing resurfacing or reconstruction. Table III-9 lists the miles and percent of total system miles that the States reported as being either at 2.0 PSR (2.5 PSR for the Interstate System) or below. Table III-9 also lists pavement at or below a PSR of 3.0. At this point, as shown in Figure III-3, pavement deterioration accelerates and will reach a PSR of 2.0 (2.5 PSR for the Interstate System) in the near future. Pavement at or above 4.0 is also included in Table III-9 to indicate the percent of total mileage that was considered new or nearly new by the States. Mileage not included in either category is considered in good condition.

Three time periods are presented in Table III-9 to illustrate trends in pavement condition. Because the span of time covered by the data is relatively short (6 years in most cases), and only three points are available, it is difficult to determine the significance of changes between time periods. In some cases, the three points in time describe a consistent trend while other sets of points indicate a reversal of trend. Generally, the report uses the 6-year period to describe changing pavement condition. Also, pavement condition data for the 1978 time period were modified after the 1981 report was published, by subtracting data from one State that obviously biased some of the national aggregate data.

Current pavement condition reports show that 4,400 miles of the Interstate System are either at or below the point (2.5 PSR) separating fair pavement from pavement needing repair, and another 5,550 miles are approaching that point (2.5-3.0 PSR). The Interstate System has 16,000 miles of very good pavement (4.0 PSR or above).

Over 38,800 miles of other arterials are either at or below a PSR of 2.0, the point separating fair pavement from pavement needing repair on non-Interstate arterials and collectors. An additional 117,600 miles of non-Interstate arterials will soon reach the 2.0 PSR condition. Over 86,000 miles of non-Interstate arterials are considered in very good condition (PSR-4.0 or above).

On the collector systems, over 134,000 miles are at or below 2.0 PSR with an additional 334,000 rapidly approaching 2.0 PSR. The collectors have 121,000 miles of very good pavement.

Note that individual State pavement condition varies considerably from the national aggregate. Figures III-4 through III-9 show the percentage of mileage, by State, that either requires immediate improvement or is rapidly approaching that point, and the percentage of mileage that is new or nearly new on the three urban and the three rural functional systems.

When considering the distribution of pavement conditions, note that the systems are not static. What was classified as rural mileage in 1975 or 1978 may be classified as

urban mileage in current data. Similarly, what may have been classified as a rural collector in 1975 or 1978 may be an arterial in current data. In each of these examples of changes in classification, formerly rural arterial and collector mileage with higher volumes generally will dominate the reclassified mileage.

Interstate Pavement

Table III-9 shows that the Interstate System is the most dynamic functional system. It is the system with the least mileage and is expanding more rapidly than any other system. Since 1975, rural Interstate mileage has increased by 10.1 percent and urban mileage has increased by 7.4 percent (3,021 miles and 638 miles, respectively).

Most of this new mileage presumably is still in "good" condition. Yet, mileage with a PSR of 4.0 or higher on the rural Interstate has decreased by 2,300 miles since 1975, despite the 3,021 new miles. Mileage at or below 2.5 PSR increased by 150 miles while mileage that will need improvement soon increased by 2,100 miles.

On the urban Interstate, mileage with a PSR rating of 2.5 or lower increased from 746 miles to 1,145 miles. Mileage with a PSR of 4.0 or higher decreased slightly, despite the opening of 638 new miles.

Note that between 1978 and 1981, Table III-9 indicates some improvement in the number of miles of urban Interstate pavement in good condition (column 4) and fair pavement that is rapidly deteriorating (column 3 minus column 2). Although this short-term trend may indicate a reduction in the rate of urban Interstate pavement deterioration, it has not, as yet, stabilized. This is borne out by the fact that since 1978, 261 miles of new urban Interstate were constructed yet only a 61-mile increase in column 4 was reported. In addition a 159-mile increase in pavement at or below 2.5 PSR has occurred since 1978.

One of the major reasons for the deterioration of Interstate pavements recorded in 1981 appears to be the increase in heavy truck traffic and the disproportionate share of that traffic carried by the Interstate. Truck travel, in general, increased at an average annual rate of 7 percent since 1975. The Interstate System carries 20 percent of all passenger vehicle miles of travel, but carries 45 percent of travel by combination trucks in rural areas and 51 percent in urban areas.[1/]

As in all Western industrialized countries, truck travel is increasing most rapidly among the heaviest vehicles. The design life of an Interstate segment typically is 20 years and is based on an anticipated number of 18,000-pound axle loading equivalents. However, with the large portion of the heaviest vehicle travel carried by the Interstate, the anticipated loadings frequently are reached in 7 to 10 years. The result is a considerably faster deterioration than that accommodated in the design stage.

1/ Highway Statistics, Table VM-1.

Arterial Pavements

Pavement conditions on rural arterials, excluding Interstate mileage, generally improved since 1975. Mileage at or below 2.0 PSR increased by only 200 miles. Mileage soon to need capital investment decreased by 6,700 miles. Mileage in good condition increased by nearly 7,000 miles (see Figure III-12). The short-term trend since 1978 indicates a considerable increase in pavement at or below a 2.0 PSR (2,369 miles) t[illegible] fewer miles of pavement that are rapidly deteriorating and more miles of rural arterial pavement considered to be in good condition.

In sum, the distribution of mileage on the Interstate shows across-the-board deterioration in pavement condition (see Figures III-10 and III-11). The percentage distribution of PSR's understates the deterioration, due to System expansion.

In urban areas, mileage in good condition increased since 1975 by 6,100 miles. At the other end of the scale, mileage at or below 2.0 PSR increased by 2,200 miles since 1975 with about half that deterioration occuring since 1978. The net effect of these changes since 1975 is a slight improvement in pavement conditions on urban arterials (see Figure III-13). This applies to the short term (since 1978) change in pavement condition, as well.

The general improvements in pavement condition on arterials reflect the high priority they have received from State capital programs. In rural areas, capital expenditure per unit of VMT on arterials approaches that for the Interstate System. With the Interstate carrying over half the rural heavy truck travel, this comparable level of capital expenditure per unit of VMT should produce somewhat more durable improvements on arterials than on the Interstate.

Collector Pavements

Pavement condition improved markedly on rural collectors for both the 6-year and 3-year periods. Since 1975, mileage with a PSR at or below 2.0 decreased by 7,000 miles and other mileage rapidly approaching that point decreased by 42,500 miles. Most of this deterioration has occurred since 1978. Mileage in very good condition increased by 28,500 miles and this improvement all took place since 1978. The degree of improvement in pavement conditions, therefore, has been significant on rural collectors, but about 50,000 miles remain in need of improvement or replacement (see Figure III-14).

In urban areas, the poorest mileage increased by 645 miles, but mileage that will soon need repair decreased by 1,500 miles. Mileage with a PSR of 4.0 or higher increased by more than 3,000 miles from 11 percent to 17 percent of the system. As with rural collectors, pavement on urban collectors improved overall since 1975 (see Figure III-15). Since 1978, the improvement is even greater. Pavement at or below 2.0 PSR decreased by 3,000 miles; at the other extreme, pavement at or above 4.0 PSR increased by 3,500 miles.

The improvements in pavement conditions on collectors clearly reflect the allocation of capital expenditure by type of improvement from State programs. Tables II-6, II-7, and II-8 indicated that a substantially larger share of capital expended on collectors was used for resurfacing than was the case on other systems. Of all capital expenditures on rural collectors in 1980 and 1981, 3R accounted for 35 percent, compared to 22.5 percent on other rural systems. The corresponding figure on collectors in urbanized areas is 28 percent, compared to 11 percent on other systems.

Pavement Condition Summary

Overall, pavement conditions deteriorated on the Interstate system, but that system still has the best pavement. Conditions improved modestly on arterials and substantially on collectors, but those systems still have large percentages that need improvements now or in the near future: 43.3 percent of rural arterials; 48.1 percent of urban arterials; 58 percent of rural collectors and 56.3 percent of urban collectors.

Figures III-10 through III-15 portray the change in condition of pavement on each of the functional systems between 1975 and 1981. The figures show the PSR for each quartile of the various functional systems. Showing each quartile permits the reader to obtain a mental picture of "25 percent of pavement is worse than first quartile" and "25 percent of pavement is better than the third quartile." A shift to the left in these figures indicates aging or deterioration for a given quartile. Note that the rural Interstate is shown to have aged the most, as all four quartiles have shifted significantly to the left.

Congestion

Congestion is measured as a peak-period volume/capacity (V/C) ratio, where volume is a count of actual traffic and capacity is the theoretical number of vehicles that can be accommodated on a road, given the number of lanes, type of traffic, alignment and other factors. The ratio is computed for morning and afternoon peak periods in urban areas and weekends and other peak-periods in rural areas. Figures III-16 and III-17 show trends in congestion. Ratios greater than .8 are generally considered to be congested.

In rural areas, congestion is not a serious problem, although 8 percent of non-Interstate arterial peak-period travel occured under congested conditions. The number of miles of the rural Interstate System that were congested during peak travel periods dropped from 685 in 1978 to 472 in 1981, possibly reflecting the addition of 1,800 new miles to the system during the period. Both the rural non-Interstate arterials and collectors had increases in the number of miles of highway experiencing congestion during peak periods since 1978 (1,640 for arterials--1,320 for collectors). It appears that the investment in pavement rehabilitation (see pages III-6 and III-7) had a higher priority for available funds than the addition of new capacity on these two rural systems.

In urban areas, there were fewer miles of congested highways during peak periods in 1981 than in 1978. The percent of travel occurring during the peak periods increased on the Interstate and remained steady on the other highways since 1978. However, congestion levels are higher on all systems since 1975. It should be noted that urban highway mileage increases as rural sections are incorporated into urban areas. These sections are generally lightly traveled and influence the number and percent of miles experiencing congestion.

Safety

Safety is a function of geometric characteristics. As noted above in this chapter, geometrics on an entire system changes relatively slowly, but if any change results from a capital improvement, the change is in a positive direction. Therefore, rather than examining system-wide indices of geometric characteristics, this section will summarize trends in the most significant indicator of road safety, i.e., highway fatalities and fatality rates.

Fatality rates clearly depend on a number of factors other than system conditions. A highway seldom "causes" an accident. Rather, driver behavior is the most common factor in accidents, with environmental factors and mechanical failures being distant seconds. Speeding and driving after drinking are the most common behavioral factors contributing to accidents, while common environmental factors include precipitation, ice, night-time driving, etc.

Highway conditions cannot make a drunk driver sober, nor can they force a driver to select a safe speed. Nevertheless, a highway with good vertical and horizontal alignment, wide lanes, shoulders, access control, etc., is better able to compensate for some of these behavioral shortcomings. Conversely, a highway with poor vertical or horizontal alignment, narrow lanes, limited shoulders, frequent at-grade crossings, etc., will be considerably less forgiving. Figures III-18 and III-19 show fatalities and fatality rates for the various functional systems for 1977 through 1980. Trends vary considerably among the systems.

Fatality rates on both the Interstate and other arterials have been essentially stable from 1977 through 1980. Fatality rates on collectors, though, were considerably more volatile and increased rapidly in both urban and rural areas from 1977 to 1980. In 1980, however, the number of fatalities per 100 million VMT on both urban and rural collectors declined. The fatality rates on urban and rural collectors are considerably higher than on arterials in their respective areas.

The generally lower geometric characteristics of collectors, compared to arterials and Interstate mileage, could explain why collectors have higher fatality rates than other systems. However, those factors do not explain the differences in the direction of the trends and in their orders of magnitude.

Other Deficiencies and Multiple Deficiencies

Pavement conditions, congestion and fatality rates are dynamic indicators of system performance and condition. However, highways also can have static deficiencies, which are partially or wholly independent of factors that change over time. Alignment and lane width, for example, are static; they are not affected by changes in travel nor by severe changes in weather. For the most part, static deficiencies are most common on the lower functional classes, which are both more extensive and older than the higher-order systems.

A considerable share of the 730,000-mile rural collector system, for example, was constructed in the 1920's and 1930's and has had relatively few capital improvements since then. Safety and design standards have long since been upgraded in response to changes in vehicle performance, vehicle size and weight, travel, etc. As a result, substantial segments of the rural collector system have substandard safety and geometric characteristics.

Tables III-10, III-11, and III-12 indicate the extent of five broad categories of deficiencies (see Table III-13 and III-14 for definitions of the deficiencies) and the mileage with one, two, or more deficiencies, whether static or dynamic. Except for the Interstate and freeways, the deficiencies are more similar than dissimilar on the different systems. There is a noticeable difference between rural and urban. This is primarily because geometry is not a factor in urban areas. Approximately 40 percent of the mileage on each system other than the Interstate and freeways has one deficiency. Approximately one-half of the urban and one-third of the rural mileage is deficiency free. The remaining mileage has more than one deficiency.

Of course, the Interstate System is the most deficiency free of all systems. This is because it was recently built to high standards, which pratically excludes geometry and cross-sectional deficiencies. Therefore, virtually all deficiencies are related to congestion or pavement condition.

The most common deficiencies in rural areas are: poor pavement on the Interstate; inadequate lane width (i.e., cross section) on other arterials; and inadequate sight distance (i.e., geometry) on collectors. In urban areas, the most common deficiencies are pavement condition and congestion on the higher-order systems and inadequate lane width on minor arterials and collectors.

Bridge Conditions

The condition of highway bridges is a subject of widespread and growing concern. If an approach road exhibits poor pavement or other deficiencies, overall performance may be only slightly impaired. If the bridge fails or is closed because of a potential hazard, however, system performance may be seriously affected since traffic must be diverted to alternate routes. In addition, a bridge failure may occur with catastrophic results. For instance, when a relatively low traffic bridge across the Ohio River failed in 1967, it claimed 46 lives. The results of highway failures, on the other hand, are never as extreme.

Bridge conditions are reported to the National Bridge Inventory (NBI) in accordance with NBI and the FHWA Highway Bridge Replacement and Rehabilitation Program (HBRRP) standards. The HBRRP, established by Congress in 1978, requires the inventory and compilation of condition information on highway bridges. All bridge information contained in this report, including cost estimates discussed in the next chapter, are derived from the HBRRP.

Table III-15 indicates the extent and nature of highway bridge deficiencies nationwide. Some 44 percent of the Nation's 550,000 highway bridges are deficient in one or more ways. The most pervasive deficiencies are either structural or deck geometrics. Over 38,000 of the 314,000 bridges on collector or arterial highways are deficient to the point of being closed or in need of immediate rehabilitation. Eighty-eight thousand of the 239,000 local road bridges are similarly structurally deficient. Over 3,400 bridges in the United States are closed to traffic altogether.

Almost one-half of all nonlocal bridges are located on collectors and 38 percent of these are considered deficient. The collector system has more, and a higher percentage of, deficient bridges than any other nonlocal system. The Interstate System has the fewest, and lowest percentage of, deficient bridges of all functional systems. While this might imply that collector deficiencies may pose a greater risk to users and a greater

potential repair bill, it should be kept in mind that Interstate bridges are, on average, busier, longer, wider and most support more severe stress than collector bridges. Repairs and/or replacement of Interstate bridges generally are more expensive and result in more travelers being inconvenienced. In addition, the selection of alternative routes for arterial and interstate travel when a bridge is placed out of service for repairs is usually more troublesome since these systems are less extensive than the collector system and since they carry higher volumes of traffic.

Highway Performance Indicators

Changes in pavement condition, congestion, accident rates, and composite indices are useful for evaluating the condition and performance of the highway system. Changes in condition affect the operational characteristics of highway segments, and these characteristics directly influence the cost of vehicle operation. Typically, highway geometry, traffic flow, surface condition, and frequency of speed changes are the most significant characteristics considered. Motor-vehicle running or operating costs, including the costs of fuel, oil, tires, maintenance, and depreciation, are used to quantify the cost of operating vehicles over a given highway design for given traffic conditions.

When vehicle operating costs are aggregated by functional or administrative systems, conclusions can be drawn concerning the effects of change in highway conditions on vehicle operating costs by system. Using the same methodology, information may also be obtained on fuel consumption by system.

The basis for determining vehicle operating costs, and fuel consumption is the effective speed of vehicles over highway segments of typical design. To determine effective speed, running speeds are first calculated for each section of highway based on typical highway geometrics, including number of lanes, median width and type, access control, average daily traffic, off-peak capacity, and whether the highway is located in a rural or urban setting.

Once the geometry is known, a matrix of highway segments displaying similar characteristics is compiled and overlaid with speed curves, traffic volume distribution tables and speed changes that reflect varying geometric and operating conditions. Once the characterization of the segment is complete and the initial running speed calculated, this speed then provides information for determining overall average highway running speed. To accomplish this, the pavement condition and the vehicle mix on the segment are factored into the base speed. This adjusted initial speed is then further modified to reflect stop and go conditions or other speed changes that would be found on the segment depending on its location, geometry, and traffic volume. The methodology allows running speeds to be calculated for each vehicle class using the facility and also calculates idle time and excess travel time due to congested conditions or signalization that produce speed changes and stops. This total travel time (speed) is translated into an effective speed for each vehicle class for a particular highway section. When the section length and the volume of traffic using the section are applied to the effective speed and accumulated, the result is a weighted effective speed for each functional class of highway, sensitive to changing pavement conditions and other operating characteristics.

The effective speed is translated directly into vehicle operating costs by summing costs per mile for vehicle operation, idling, and speed changes and accumulated in the same manner as with effective speed. The final vehicle operating cost includes all direct

costs of fuel, oil, and tires as well as excessive wear and maintenance required as a result of pavement or structural deterioration. The costs reported here do not include values of travel time. Factoring in a value of travel time by vehicle type is not a complex procedure. The problem lies in assigning values of time that all transportation interests could find acceptable and equitable since such an analysis may be used in multimodal transportation investment decisionmaking. For the purposes of this report, it suffices to evaluate impacts in a relative sense and assume only that a decrease in effective speed translates as an increase in congestion and travel costs, and vice versa. Fuel consumption is quantified in like fashion, based on the effective speed, speed changes, idling, vehicle type and mix, pavement condition, traffic volume distribution (v/c), and facility type.[1/]

Table III-16 summarizes changes in the performance of various vehicle types on the highway system from 1978 to current conditions. The price of fuel and changes in fleet fuel consumption rates as components of operating cost were held constant over the analysis period so as not to mask the effects of changed operating conditions on the system. The table shows only slight changes in overall system performance, as would be expected for a short-term analysis.

1/ All base types for computing impacts other than emissions are from the Highway Investment Analysis Package, Volume II, June 1979 (FHWA-PL-79-014). Emission factors are taken from "Mobile Source Emission Factor Tables" published by FHWA in 1978.

Table III-1
Mileage and Travel by Functional System[1/]
December 31, 1981

Rural Summary	Miles	Percent of Rural	Percent of Total	Million* VMT	Percent of Rural	Percent of Total
Principal Arterial[2/]						
Interstate	32,959	1.0	0.9	138,395	20.1	8.9
Other	81,655	2.5	2.1	135,463	19.7	8.7
Minor Arterial	148,826	4.6	3.9	132,407	19.3	8.5
Collector						
Major	440,409	13.7	11.4	154,254	22.5	10.0
Minor	299,515	9.3	7.8	41,331	6.0	2.7
Rural Subtotal	1,003,364	31.2	26.0	601,850	87.6	38.8
Local Roads	2,217,320	68.8	57.6	85,049	12.4	5.5
RURAL TOTAL	3,220,684	100.0	83.6	686,899	100.0	44.3

Total Urban Summary	Miles	Percent of Urban	Percent of Total	Million VMT	Percent of Urban	Percent of Total
Principal Arterial[2/]						
Interstate	9,309	1.5	0.2	166,817	19.3	10.8
Other Freeways & Expressways	6,802	1.1	0.2	82,051	9.5	5.3
Other	44,889	7.1	1.2	234,309	27.1	15.1
Minor Arterial	66,086	10.5	1.7	173,088	20.0	11.2
Collectors	69,109	10.9	1.8	81,705	9.5	5.3
Urban Subtotal	196,195	31.0	5.1	737,970	85.5	47.6
Local Roads	435,818	69.0	11.3	125,402	14.5	8.1
URBAN TOTAL	632,013	100.0	16.4	863,372	100.0	55.7
TOTAL (URBAN & RURAL)	3,852,697		100.0	1,550,271		100.0

*Million of vehicle miles traveled (MVMT).

1/ As obtained from HPMS universe data from reports of 48 States (38 for 1981 and 10 for 1980). Data factored to nationwide levels. Following States not included in based data: District of Columbia, Mississippi, and Rhode Island. Because of factoring procedures used, individual components may not be compatible among the various mileage tables.

2/ Although the Interstate System is part of the principal arterial functional system, its mileage is shown separately.

Table III-2
Federal-aid System Mileage Characteristics[1/] [2/]

Functional Class	Miles by Functional Class	Interstate[3/]		Primary			Secondary (No Urban)			Non-Federal-aid[4/]		
		Miles	% of Total	Miles	% of Total	% of Funct. System	Miles	% of Total	% of Funct. System	Miles	% of Total	% of Funct. System
Rural												
Interstate	32,959	32,959	2.7	---	---	---	---	---	---	---	---	---
Other Principal Arterial	81,655	---	---	80,490	6.7	98.6	---	---	---	1,165	0.1	1.4
Minor Arterials	148,826	---	---	146,867	12.2	98.7	---	---	---	1,959	0.2	1.3
Major Collectors	440,409	---	--	---	---	---	400,823	33.4	91.0	39,586	3.3	9.0
Minor Collectors	299,515	---	---	---	---	---	---	---	---	299,515	25.0	100.0
Subtotals (Rural)	1,003,364	32,959	2.7	227,357	18.9		400,823	33.4		342,225	28.5	
							Urban System (No Rural)					
Urban												
Interstate	9,309	9,309	0.8	---	---	---	---	---	---	---	---	---
Other Freeway & Expressway	6,802	---	---	5,352	0.4	78.7	649	0.1	9.4	801	0.1	11.8
Other Principal Arterial	44,889	---	---	22,077	1.8	49.2	18,353	1.5	40.9	4,459	0.4	9.9
Minor Arterial	66,086	---	---	1,202	0.1	1.8	56,661	4.7	85.7	8,223	0.7	12.4
Collectors	69,109	---	---	---	---	---	53,784	4.5	77.8	15,325	1.3	22.2
Subtotals (Urban)	196,195	9,309	0.8	28,631	2.4		129,447	10.8		28,808	2.4	
Totals (Rural & Urban)	1,199,559	42,268	3.5	255,988	21.3		129,447	10.8		371,033	30.9	

1/ Excludes local road mileage because no local roads are on a Federal-aid system.

2/ As obtained from HPMS universe data.

3/ Although the Interstate System is part of the Federal-aid primary system, its mileage is shown separately.

4/ Non-Federal-aid information is provided to permit comparison tc functional systems.

Table III-3
Federal-aid System Travel Characteristics[1/]
(Million vehicle-miles-of-travel (MVMT))

Functional Class	Travel by Functional Class (MVMT)	Interstate		Other Primary			Secondary (No Urban)			Non-Federal-aid[2/]		
		MVMT	% of Total	MVMT	% of Total	% of Funct. System	MVMT	% of Total	% of Funct. System	MVMT	% of Total	% of Funct. System
Rural												
Interstate	138,395	138,395	10.3	---	---	---	---	---	---	---	---	---
Other Principal Arterials	135,463	---	---	134,137	10.0	99.0	---	---	---	1,326	0.1	1.0
Minor Arterials	132,407	---	---	129,911	9.7	98.1	---	---	---	2,496	0.2	1.9
Major Collectors	154,254	---	---	---	---	---	142,510	10.6	92.4	11,744	0.9	7.6
Minor Collectors	41,331	---	---	---	---	---	---	---	---	41,331	3.1	100.0
Subtotals (Rural)	601,850	138,395	10.3	264,048	19.7		142,510	10.6		56,897	4.2	
							Urban System (No Rural)					
Urban												
Interstate	166,817	166,817	12.5	---	---	---	---	---	---	---	---	---
Other Freeway & Expressway	82,051	---	---	67,411	5.0	82.2	9,986	0.7	12.2	4,654	0.3	5.7
Other Principal Arterials	234,309	---	---	120,264	9.0	51.3	98,627	7.4	42.1	15,418	1.2	6.6
Minor Arterials	173,088	---	---	5,239	0.4	3.0	158,056	11.8	91.3	9,793	0.7	5.7
Collectors	81,705	---	---	---	---	---	60,665	4.5	74.2	21,040	1.6	25.8
Subtotals (Urban)	737,970	166,817	12.5	192,914	14.4		327,334	24.4		50,905	3.8	
TOTALS (Rural & Urban)	1,339,820	305,212	22.8	456,962	34.1					107,802	8.0	

1/ Excludes local travel because no local travel is on a Federal-aid system.

2/ Non-Federal-aid information is provided to permit comparison to functional systems.

Table III-4
Highway Mileage Comparison (1975-1981)

Rural Summary	1975 Miles	1981 Miles	1975-1981 Comparison: Change in Miles	1975-1981 Comparison: Percent Change
Principal Arterial				
Interstate	29,938	32,959	+3,021	+10.1
Other	82,132	81,655	-477	-.5
Minor Arterial	152,573	148,826	-3,747	-2.5
Collector				
Major Collector	430,950	440,409	+9,459	+2.2
Minor Collector	306,798	299,515	-7,283	-2.4
Rural Subtotal	1,002,391	1,003,364	+973	+.1
Local Roads	2,127,938	2,217,320	+89,382	+4.2
RURAL TOTAL	3,130,329	3,220,684	+90,355	+2.9
Total Urban Summary				
Principal Arterial				
Interstate	8,671	9,309	+638	+7.4
Other Freeway & Expressway	6,480	6,802	+322	+5.0
Other Principal Arterials	44,515	44,889	+374	+.8
Minor Arterial	64,516	66,086	+1,570	+2.4
Collectors	65,209	69,109	+3,900	+6.0
Urban Subtotal	189,391	196,195	+6,804	+3.6
Local Roads	397,894	435,818	37,924	+9.5
URBAN TOTAL	587,285	632,013	44,728	+7.6
TOTAL (Rural & Urban)	3,717,614	3,852,697	+135,083	+3.6

Table III-5
Travel Growth (1975-1981)
(Million vehicle-miles-of-travel (MVMT))

Rural Summary	1975 MVMT	1981 MVMT	1975-1981 Comparison: Actual Change in MVMT	1975-1981 Comparison: Percent Change in MVMT
Principal Arterial				
Interstate	117,137	138,395	+21,258	+18.1
Other	122,462	135,463	+13,001	+10.6
Minor Arterial	124,848	132,407	+7,559	+6.1
Collector				
Major	127,590	154,254	+26,664	+20.9
Minor	37,379	41,331	+3,952	+10.6
Rural Subtotal	529,416	601,850	+72,434	+13.7
Local Roads	73,056	85,049	+11,993	+16.4
RURAL TOTAL	602,472	686,899	+84,427	+14.0
Total Urban Summary				
Principal Arterial				
Interstate	128,417	166,817	+38,400	+29.9
Other Freeway & Expressway	76,017	82,051	+6,034	+7.9
Other Principal Arterials	207,693	234,309	+26,616	+12.8
Minor Arterial	147,975	173,088	+25,113	+17.0
Collectors	66,950	81,705	+14,755	+22.0
Urban Subtotal	627,053	737,970	+110,917	+17.7
Local Roads	102,768	125,402	+22,634	+22.0
URBAN TOTAL	729,821	863,372	+133,551	+18.3
TOTAL (Rural & Urban)	1,332,293	1,550,271	+217,978	+16.4

Table III-6
Most Recent Year of HPMS Data Used in Report from Each State

1981 Data (34 States)

Alabama	Maine	Oregon
Colorado	Massachusetts	Pennsylvania
Connecticut	Minnesota	South Dakota
Delaware	Montana	Tennessee
Florida	Nebraska	Utah
Hawaii	Nevada	Virginia
Idaho	New Hampshire	Washington
Illinois	New Jersey	West Virginia
Indiana	New Mexico	Wisconsin
Kansas	New York	Wyoming
Kentucky	North Carolina	
Louisiana	North Dakota	

1980 Data (9 States)

Arizona	Maryland	Vermont
California*	Michigan	
Georgia	Missouri*	
Iowa	Texas	

1978 Data (3 States & D.C.)

Arkansas	District of Columbia	South Carolina
	Ohio	

No Data Used (4 States)

Alaska**	Oklahoma	Rhode Island
Mississippi		

*Partial data - some functional classes not reported.

**Alaska's 1978 data was not used due to substantial changes since 1978 in its systems.

Table III-7
Deterioration Index[1/]
(Weighed by Miles)

	1975	1978	Current
Rural			
Interstate	74.3	72.5	71.4
Arterials	71.7	71.8	70.2
Collectors	71.8	71.6	70.7
Urban			
Interstate	63.7	61.3	62.0
Arterials	62.4	61.0	60.7
Collectors	69.6	68.2	68.4
Average	70.6	70.3	69.4

1/ An index derived from combining aggregate system pavement condition and peak period volume-capacity ratio. Increases in index indicate improving conditions.

Table III-8
Deterioration Index[1/]
(Weighed by Travel)

	1975	1978	Current
Rural			
Interstate	66.7	65.5	63.3
Arterials	66.5	66.2	62.9
Collectors	67.1	67.3	64.9
Urban			
Interstate	53.0	51.8	49.0
Arterials	54.1	52.8	52.2
Collectors	63.2	60.2	59.8
Average	60.3	59.6	57.7

1/ An index derived from combining aggregate system pavement condition and peak period volume-capacity ratio. Increases in index indicate improving conditions.

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Table III-9
Estimated Miles of Highway by Pavement Condition[1] and Year

Functional System and Year	1	2		3[3]		4	
	Total Miles	Less than or Equal to 2.0 PSR[2]		Less than or Equal to 3.0 PSR		Greater than or Equal to 4.0 PSR	
		Miles	Percent	Miles	Percent	Miles	Percent
Interstate - Rural							
1975	29,938	3,113	10.4	5,455	18.2	14,887	49.7
1978	31,161	3,116	10.0	7,603	24.4	13,339	43.0
Current	32,959	3,263	9.9	7,614	23.1	12,590	38.2
Interstate - Urban							
1975	8,671	746	8.6	1,932	22.3	3,517	40.6
1978	9,048	986	10.9	2,461	27.2	3,420	37.8
Current	9,309	1,145	12.3	2,346	25.2	3,509	37.7
Other Arterials - Rural							
1975	234,705	26,052	11.1	106,338	45.3	52,754	22.5
1978	232,096	23,906	10.3	112,799	48.6	56,167	24.2
Current	230,481	26,275	11.4	99,798	43.3	59,695	25.9
Other Arterials - Urban							
1975	115,511	10,396	9.0	54,737	47.4	20,280	17.6
1978	117,559	11,521	9.8	59,838	50.9	25,275	21.5
Current	117,777	12,602	10.7	56,651	48.1	26,382	22.4
Collectors - Rural							
1975	737,748	132,057	17.9	478,703	64.9	80,997	11.0
1978	734,678	130,038	17.7	479,745	65.3	80,815	11.0
Current	739,924	125,047	16.9	429,156	58.0	109,509	14.8
Collectors - Urban							
1975	65,209	8,477	13.0	39,842	61.1	6,944	10.6
1978	67,292	12,381	18.4	44,816	66.6	7,940	11.8
Current	69,109	9,122	13.2	38,908	56.3	11,403	16.5

1/ Condition is measured by Present Serviceability Rating (PSR) - 2.0 (2.5 for Interstate) marks the point between pavement in fair condition and poor condition - 3.0 is the point where rapid deterioration can be expected - 4.0 and above identifies new or nearly new pavement. (See page III-29 for more detailed description).

2/ 2.5 for Interstate

3/ Miles in this column include miles in Column 2.

Table III-10
Federal-Aid Systems
1981 Deficiency Summary[1/]
(Estimated Mileage and Percent)

Deficiency	Interstate		Federal-aid Primary		Federal-aid Secondary		Urban Systems		Total	
	Miles	Percent	Miles	Percent	Miles	Percent	Miles	Percent	Miles	Percent
Pavement	4,408	10.4	41,133	16.1	56,441	16.2	19,097	15.0	120,969	15.6
Geometry	501	1.2	36,928	14.4	137,967	39.6	---	---	175,396	22.7
Cross Section	1,951	4.6	117,440	45.9	134,135	38.5	43,623	34.2	297,149	38.4
Operational	4,652	11.0	49,016	19.2	12,891	3.7	18,218	14.3	84,777	11.0
Access Control	29	0.1	353	0.1	---	---	42	0.0	426	0.1
Miles with a single deficiency	7,524	17.8	106,210	41.5	139,709	40.1	51,807	40.7	305,250	39.4
Miles with more than one deficiency	1,892	4.5	61,285	23.9	92,327	26.5	14,287	11.2	169,791	21.9
Total miles with deficiencies	9,416	22.3	167,495	65.5	232,036	66.6	66,094	51.9	475,041	61.4
Total miles without deficiencies	32,852	77.7	88,395	34.5	116,366	33.4	61,319	48.1	298,932	38.6
TOTAL (100%)	42,268		255,890		348,402		127,413		773,973	

1/ Unpaved sections were not included in this analysis.

Table III-11
Urban Functional Systems
1981 Deficiency Summary[1]
(Estimated Mileage and Percent)

Deficiency	Interstate		Freeways & Expressways		Other Principal Arterials		Minor Arterials		Collectors		Total	
	Miles	Percent	Miles	Percent	Miles	Percent	Miles	Percent	Miles	Percent	Miles	Percent
Pavement	1,145	12.3	957	14.1	10,368	23.1	8,095	12.4	10,063	14.9	30,702	15.8
Cross Section	488	5.2	1,092	16.1	12,288	27.4	20,304	31.0	27,112	40.2	61,284	31.6
Operational	2,331	25.0	1,862	27.4	12,969	28.9	10,399	15.9	4,919	7.3	32,480	16.8
Access Control	5	0.1	448	6.6	---	---	---	---	---	---	453	0.2
Miles with a single deficiency	2,762	29.7	1,976	29.0	18,437	41.1	25,394	38.8	28,685	42.5	77,254	39.9
Miles with more than one deficiency	629	6.8	1,053	15.5	8,126	18.1	6,635	10.1	6,656	9.9	23,099	11.9
Total miles with deficiencies	3,391	36.4	3,029	44.5	26,563	59.2	32,029	49.0	32,259	47.8	97,271	50.2
Total miles without deficiencies	5,918	63.6	3,773	55.5	18,296	40.8	33,369	51.0	35,193	52.2	96,549	49.8
TOTAL (100%)	9,309		6,802		44,859		65,398		67,452		193,820	

1/ Unpaved sections were not included in this analysis.

Table III-12
Rural Functional Systems
1981 Deficiency Summary[1/]
(Estimated Mileage and Percent)

Deficiency	Interstate		Other Principal Arterials		Minor Arterials		Major Collectors		Minor Collectors		Total	
	Miles	Percent	Miles	Percent	Miles	Percent	Miles	Percent	Miles	Percent	Miles	Percent
Pavement	3,263	9.9	17,970	22.0	17,644	11.9	61,285	16.2	45,890	25.3	145,868	17.7
Geometry	501	1.5	8,566	10.5	28,857	19.4	150,087	39.6	81,205	44.7	269,216	32.7
Cross Section	1,463	4.4	31,553	38.7	80,100	53.9	146,001	38.5	66,211	36.4	325,328	39.5
Operational	2,321	7.0	25,018	30.6	16,530	11.1	13,961	3.7	3,350	1.8	61,180	7.4
Access Control	24	0.1	---	---	---	---	---	---	---	---	24	----
Miles with a single deficiency	4,762	14.4	32,587	39.9	63,825	42.9	151,784	40.1	71,971	39.6	324,929	39.4
Miles with more than one deficiency	1,263	3.8	21,745	26.6	35,357	23.8	100,275	26.5	55,208	30.4	213,848	26.0
Total miles with deficiencies	6,025	18.3	54,332	66.6	99,183	66.7	252,059	66.5	127,179	70.0	538,778	65.4
Total miles without deficiencies	26,934	81.7	27,306	33.4	49,464	33.3	126,898	33.5	54,480	30.0	285,182	34.6
TOTAL PAVED MILES	32,959		81,638		148,647		378,957		181,659		823,860	

[1/] Unpaved sections were not included in this analysis.

Table III-13
1981 HPMS Deficiency Analysis
Rural Minimum Tolerable Condition Table

Highway Charteristic	PRINCIPAL ARTERIALS			MINOR ARTERIALS									MAJOR AND MINOR COLLECTORS											
	All Average Daily Traffic (ADT)			ADT 6000 +			ADT 2000 - 6000			ADT Less than 2000			ADT 1000 +			ADT 500 - 1000			ADT 200 - 499			ADT Less than 200		
Terrain[1/]	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M	F	R	M
Lane Width (ft.)	11	11	11	10	10	10	10	10	10	10	10	10	10	10	10	9	9	9	8	8	8	16[2/]	16[2/]	16[2/]
Right Shoulder Width (ft.)	8	8	6	8	8	6	6	6	4	6	6	4	4	4	4	4	4	4	2	2	2	0	0	0
Shoulder Type[3/]	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	3	3	3	3	3	3
Pavement Condition	3.0	3.0	3.0	2.6	2.6	2.6	2.4	2.4	2.4	2.4	2.4	2.4	2.0	2.0	2.0	2.0	2.0	2.0	1.8	1.8	1.8	1.8	1.8	1.8
Operating Speed[4/]	45	40	35	40	35	30	40	35	30	30	30	25	30	25	20	---	---	---	---	---	---	---	---	---
V/C Ratio[4/]	.85	.85	.85	.85	.85	.85	.85	.85	.85	.85	.85	.85	.85	.85	.85	---	---	---	---	---	---	---	---	---
Surface Type[5/]	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3	4	4	4	4	4	4	5	5	5
Horizontal Alignment[6/]	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3
Vertical Alignment[7/]	2	2	2	2	2	2	2	2	2	2	2	2	2	2	2	3	3	3	3	3	3	3	3	3

1/ Terrain types are Flat, Rolling, and Mountainous.
2/ For collectors with less than 200 ADT, surface width is used instead of lane width.
3/ Code 2: Stabilized; Code 3: Earth
4/ V/C Ratio is used only for sections in densely developed areas. Operating speed is usually used in rural areas.
5/ Code 2: High Flexible; Code 3: Intermediate; Code 4: Low; Code 5: Gravel
6/ Code 2: All curves can be safely and comfortably negotiated at the prevailing speed limit; Code 3: Some curves might require reduced speed.
7/ Code 2: All grades and vertical curves provide sufficient sight distance for safe travel and do not substantially affect the speed of trucks; Code 3: Infrequent occurrances of limited sight distance and slow trucks on hills..

Table III-14
1981 HPMS Deficiency Analysis
Urban Minimum Tolerable Condition Table

Highway Characteristic	Interstate	Other Freeways & Expressways	Other Principal Arterials	Minor Arterials	Collectors
Operating Speed:					
Built-Up Areas	30	30	---	---	---
Outlying Areas	30	30	---	---	---
Volume-to-Capacity-Ratio	.90	.90	.90	.95	.95
Lane Width (ft.)	11	10	10	8	8
Surface Type[1/]	2	2	2	3	4
Pavement Condition (PSR)	3.2	3.0	2.8	2.4	2.0
Shoulder Type[2/]	1	1	2	3	3
Right Shoulder Width (ft.)	8	8	6	6	6

1/ Code 2: High flexible; Code 3: Intermedate; Code 4: Low

2/ Code 1: Surfaced; Code 2: Stabilized; Code 3: Earth

Table III-15
Deficient Bridge Summary by Functional Classes

	Rural		Urban		Total	
	Number	Cumulative Percent	Number	Cumulative Percent	Number	Cumulative Percent
Interstate						
Structurally deficient	809	3.1	1,048	5.3	1,857	4.0
Structural condition	123	3.5	137	6.0	260	4.6
Deck geometry	836	6.7	837	10.2	1,673	8.2
Underclearance	590	8.9	466	12.5	1,056	10.4
Waterway adequacy	31	9.0	11	12.6	42	10.5
Approach road alignment	16	9.1	19	12.7	35	10.6
TOTAL DEFICIENT INTERSTATE BRIDGES	2,405	9.1	2,518	12.7	4,923	10.6
TOTAL INTERSTATE BRIDGES	26,474		19,903		46,377	
Arterials*						
Structurally deficient	6,931	9.3	4,772	11.4	11,703	10.1
Structural condition	2,179	12.3	964	13.7	3,143	12.8
Deck geometry	9,083	24.5	3,912	23.1	12,995	24.0
Underclearance	322	24.9	943	25.3	1,265	25.1
Waterway adequacy	254	25.3	93	25.5	347	25.4
Approach road alignment	319	25.7	237	26.1	556	25.8
TOTAL DEFICIENT ARTERIAL[1/] BRIDGES	19,088	25.7	10,921	26.1	30,009	25.8
TOTAL ARTERIAL BRIDGES	74,327		41,843		116,170	

1/ Excluding Interstate

Remarks

A bridge was counted only once* as being deficient based on the following two priorities:

1. Structurally deficient (closed, restricted to light vehicles only, or in need of immediate rehabilitation to remain open).
2. Functionally obsolete (can no longer safely service the system on which it is located) due to:**
   a. Structural condition (original design load is less than current standards).
   b. Deck geometry (bridge narrower than roadway and inadequate vertical or horizontal clearance).
   c. Underclearance (horizontal or vertical).
   d. Waterway adequacy.
   e. Approach road alignment.

*To avoid multiple counting of deficient bridges.

**It should not be assumed that any of the (a thru e) functionally obsolete factors are more undersirable than any other.

Table III-15 (continued)

	Rural		Urban		Total		Summary: Rural and Urban All Functional Systems	
	Number	Cumulative Percent	Number	Cumulative Percent	Number	Cumulative Percent	Number	Cumulative Percent
Collectors								
Structurally deficient	23,130	16.3	1,663	16.5	24,793	16.4	38,353	12.2
Structural condition	8,338	22.2	165	18.1	8,503	22.0	11,906	16.0
Deck geometry	19,889	36.3	1,251	30.6	21,140	35.9	35,808	27.4
Underclearance	298	36.5	100	31.6	398	36.2	2,719	28.3
Waterway adequacy	858	37.1	48	32.0	906	36.8	1,295	28.7
Approach road alignment	1,826	38.4	84	32.9	1,910	38.0	2,501	29.5
TOTAL DEFICIENT COLLECTOR BRIDGES	54,339	38.4	3,311	32.9	57,650	38.0	92,582	29.5
TOTAL COLLECTOR BRIDGES	141,503		10,075		151,578		314,125	
TOTAL BRIDGES (ALL SYSTEMS)	242,304		71,821		314,125			
							Summary: All Highways Plus Local Roads	
Local Roads[2/]								
Structurally deficient	83,595	38.1	4,819	24.5	88,414	37.0	126,767	22.9
Functionally obsolete	59,744	65.3	3,501	42.2	63,245	63.4	117,767	44.1
TOTAL DEFICIENT LOCAL ROAD BRIDGES	143,339	65.3	8,320	42.2	151,659	63.4	244,241	44.1
TOTAL LOCAL ROAD BRIDGES	291,480		19,705		239,185			
TOTAL	461,784		91,526		553,310		553,310	

2/ Excludes all bridges on arterials and collectors, as this table and chapter are based on functional systems. Therefore, "local" data will differ from "off-system" data in the Fourth Annual Report to Congress on the Highway Bridge Replacement and Rehabilitation Programs.

Table III-16
Highway Performance Measures
(Automobiles, Pickups, and Vans)
1978 to Current[1/]

	Effective Speed[2/]		Operating Cost[3/]		Fuel Consumption[4/]	
Rural	1978	Current[1/]	1978	Current[1/]	1978	Current[1/]
Interstate	55.3	57.2	168.7	169.8	70.3	71.2
Other Principal Arterials	43.5	44.1	172.0	172.6	70.1	70.4
Minor Arterials	39.5	39.4	171.0	172.0	67.7	68.3
Major Collectors	33.9	32.8	185.7	185.4	69.8	69.6
Minor Collectors	27.4	27.7	213.5	210.3	74.2	73.4
Urban						
Interstate	43.4	46.3	162.7	163.4	63.0	64.2
Other Freeways and Expressways	38.8	42.1	167.5	168.7	64.4	65.4
Other Principal Arterials	17.9	18.2	206.8	206.6	80.6	80.3
Minor Arterials	18.7	19.0	211.8	210.2	82.0	81.7
Collectors	18.3	18.5	218.1	216.8	83.1	82.9

1/ Table III-6 lists the year of data used for each State, all of which is referred to as "current" data in this report.

2/ Miles-per-hour.

3/ $/1,000 VMT

4/ Gallons/1,000 VMT

Figure III-1
Present Serviceability Rating (PSR)

PSR	Verbal Rating	Description
5	Very Good	Only new (or nearly new) pavements are likely to be smooth enough and sufficiently free of cracks and patches to qualify for this category. All pavements constructed or resurfaced recently should be rated very good.
4	Good	Pavements in this category, although not quite as smooth as those described above, give first-class ride and exhibit few, if any visible signs of surface deterioration. Flexible pavements may be beginning to show evidence of rutting and fine random cracks. Rigid pavements may be beginning to show evidence of slight surface deterioration, such as minor cracks and spalling.
3	Fair	The riding qualities of pavements in this category are noticeably inferior to those of new pavements, and may be barely tolerable for high-speed traffic. Surface defects of flexible pavements may include rutting, map cracking, and more or less extensive patching. Rigid pavements in this group may have a few joint failures, faulting and cracking, and some pumping.
2	Poor	Pavements that have deteriorated to such an extent that they are in need of resurfacing.
1	Very Poor	Pavements which are in an extremely deteriorated condition and may even need complete reconstruction.
0		

Figure III-2
Sequence of Deterioration

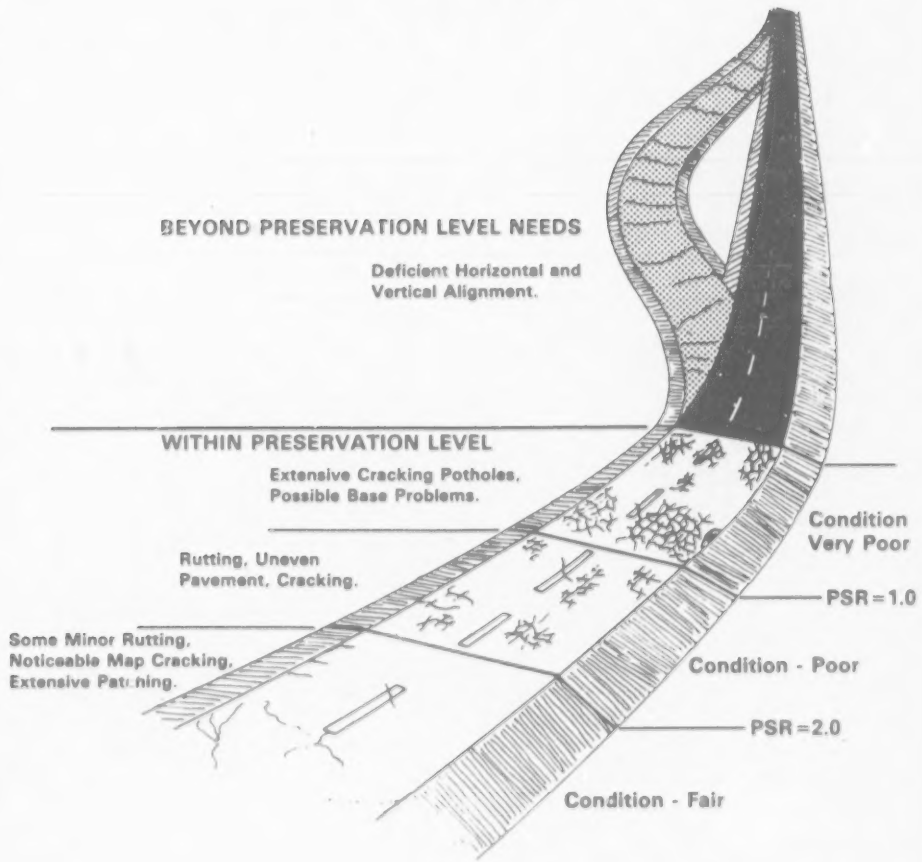
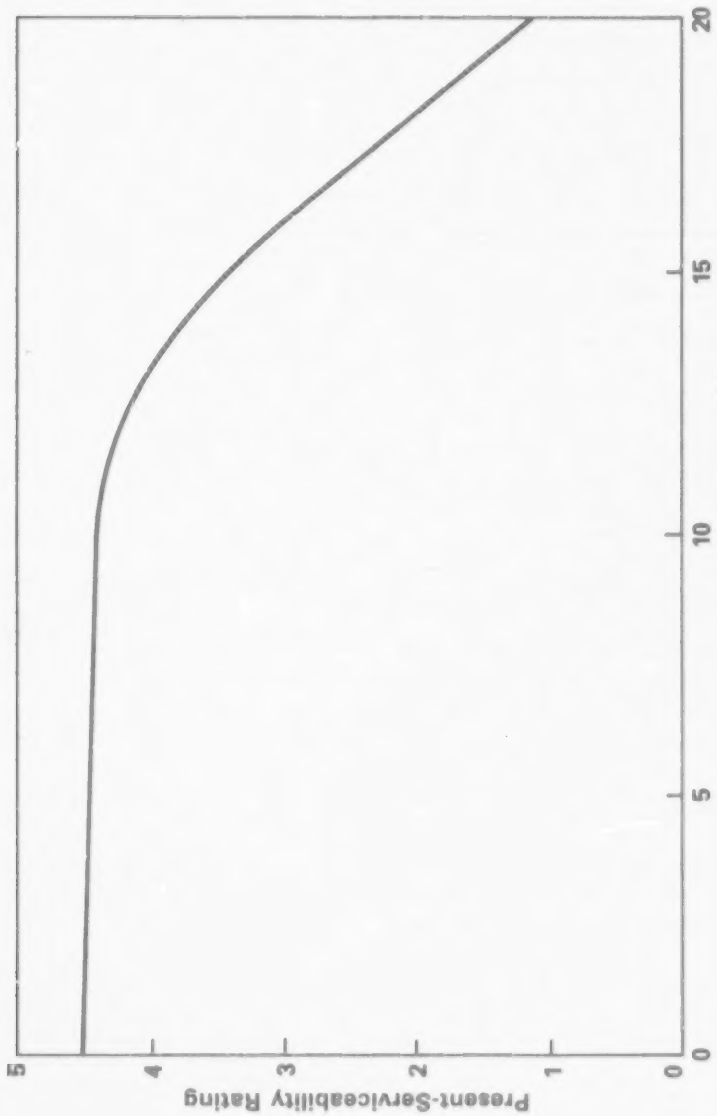

BEYOND PRESERVATION LEVEL NEEDS
Deficient Horizontal and Vertical Alignment.
WITHIN PRESERVATION LEVEL
Extensive Cracking Potholes, Possible Base Problems.
Rutting, Uneven Pavement, Cracking.
Some Minor Rutting, Noticeable Map Cracking, Extensive Patching.
Condition Very Poor
PSR = 1.0
Condition - Poor
PSR = 2.0
Condition - Fair

Figure III-3
Typical Pavement Aging Process[1/]



1/ "A System for Estimating Present Surface Conditions and Remaining Service Life of Existing Pavement Sections", *Public Roads*, Vol. 36, No. 5.

2/ Varies depending on conditions and pavement design

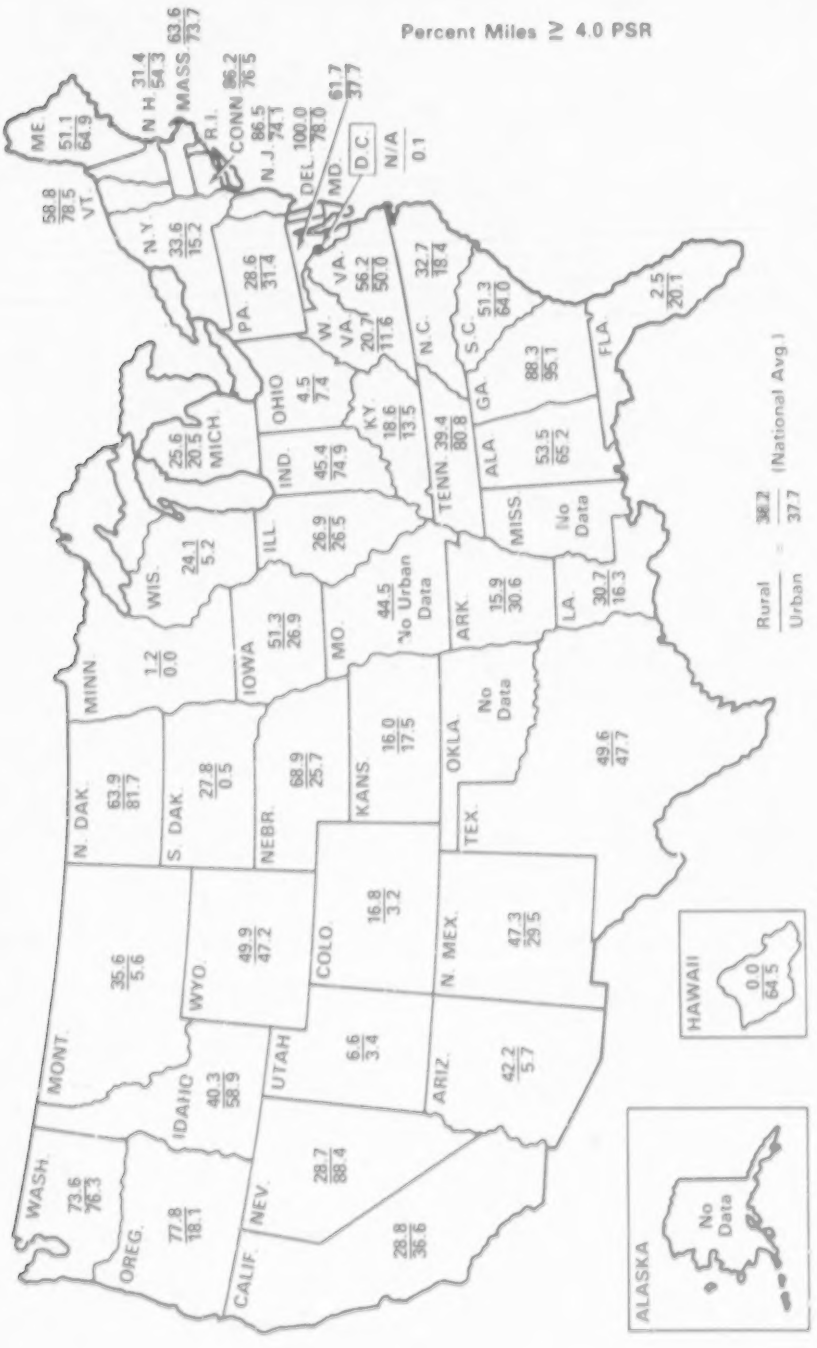
Figure III-4
Current Pavement Condition on the Interstate

Figure III-5
Current Pavement Condition on Arterials*

*Excludes Interstate

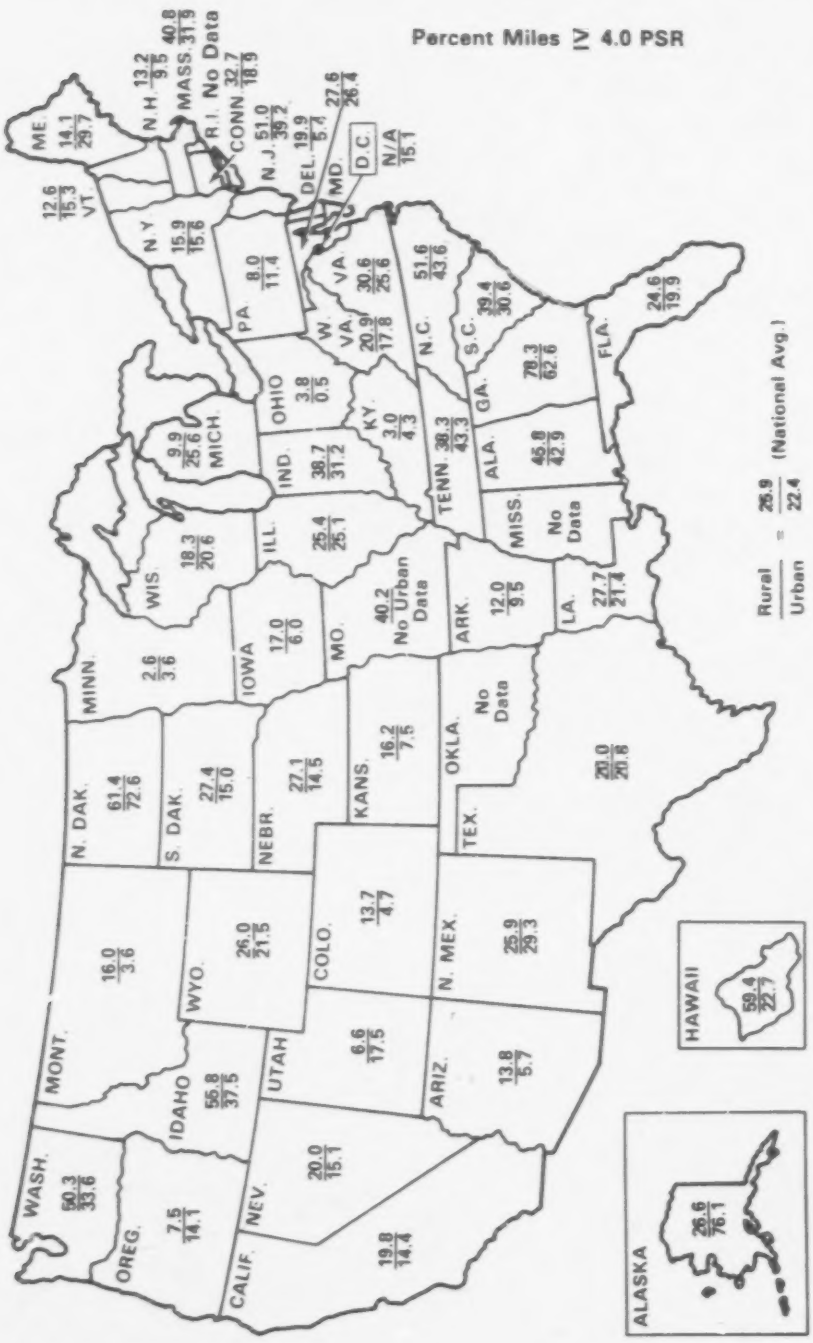
Figure III-6
Current Pavement Condition on Collectors

Figure III-7
Current Interstate Pavement in Nearly New Condition



23-425 0 - 83 - 7

Figure III-8
Current Arterial Pavement in Nearly New Condition*



*Excludes Interstate

Figure III-9
Current Collector Pavement in Nearly New Condition

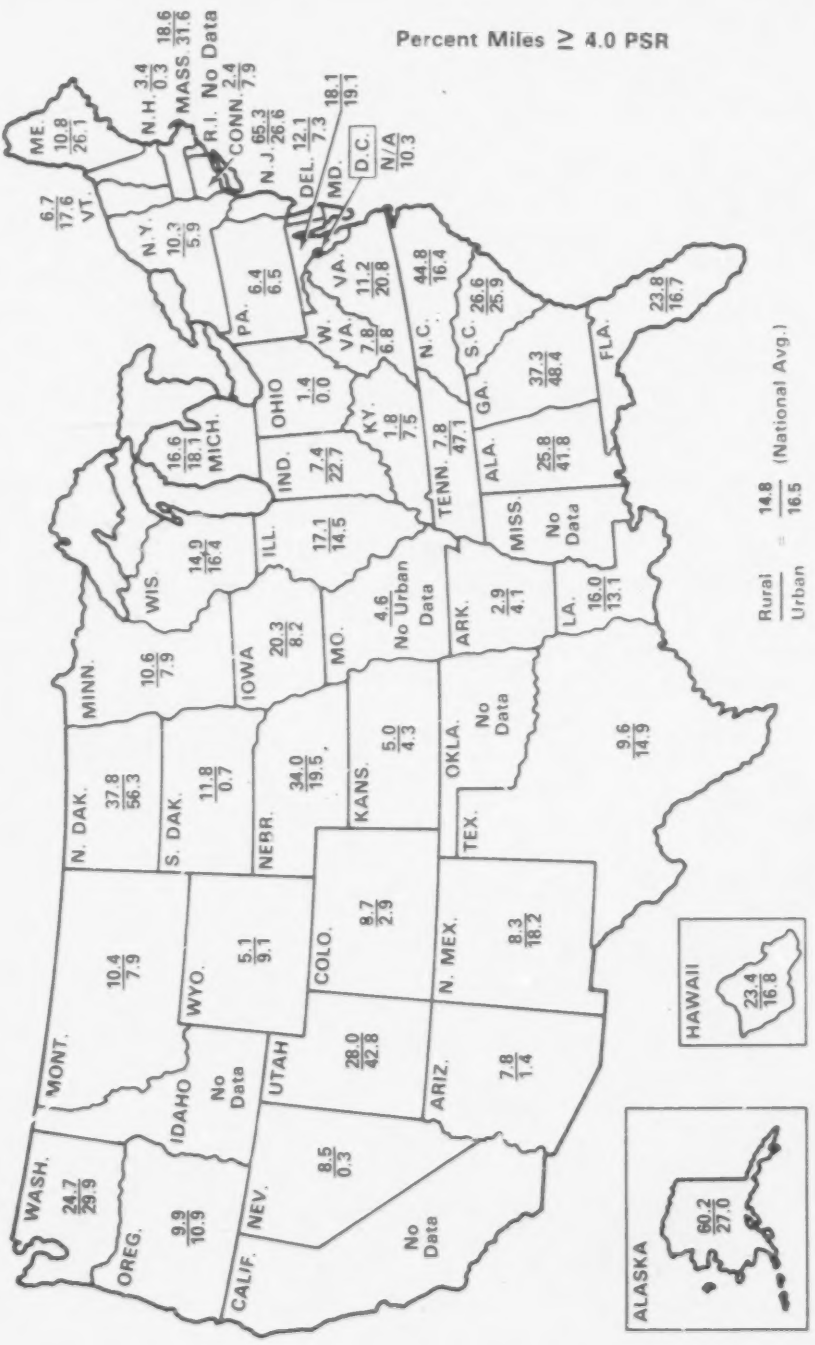


Figure III-10
Rural Interstate Pavement Condition Trends

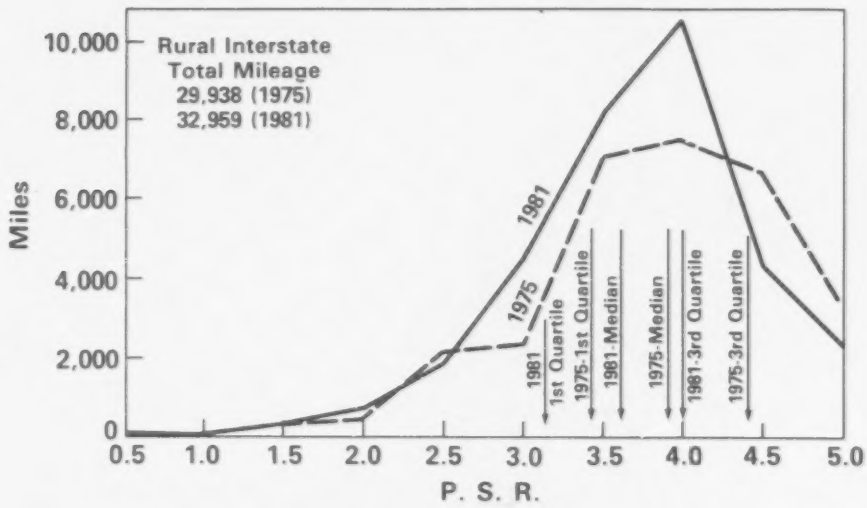


Figure III-11
Urban Interstate Pavement Condition Trends

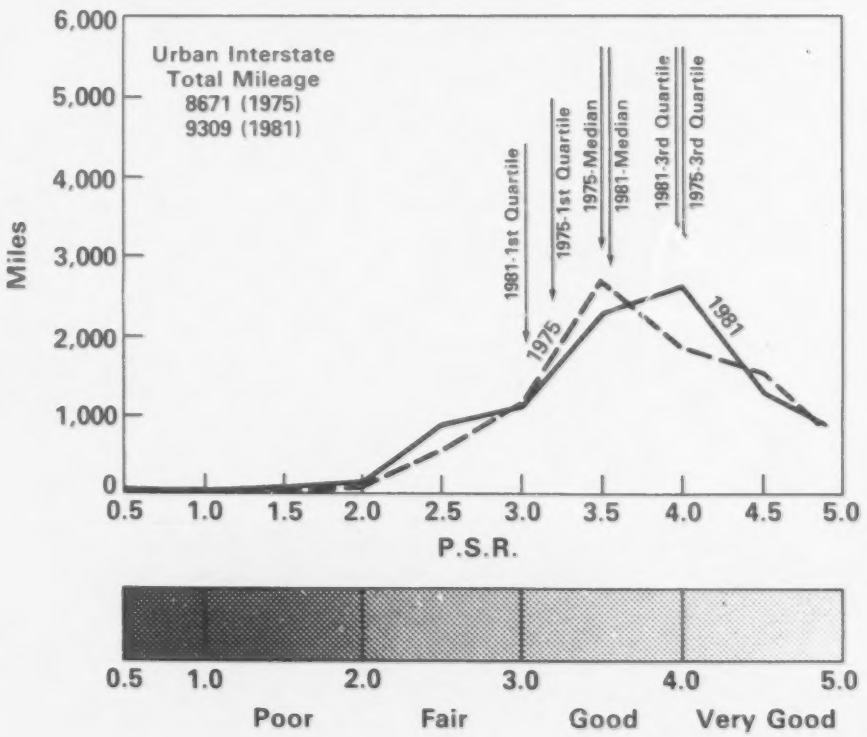


Figure III-12
Rural Arterial Pavement Condition Trends

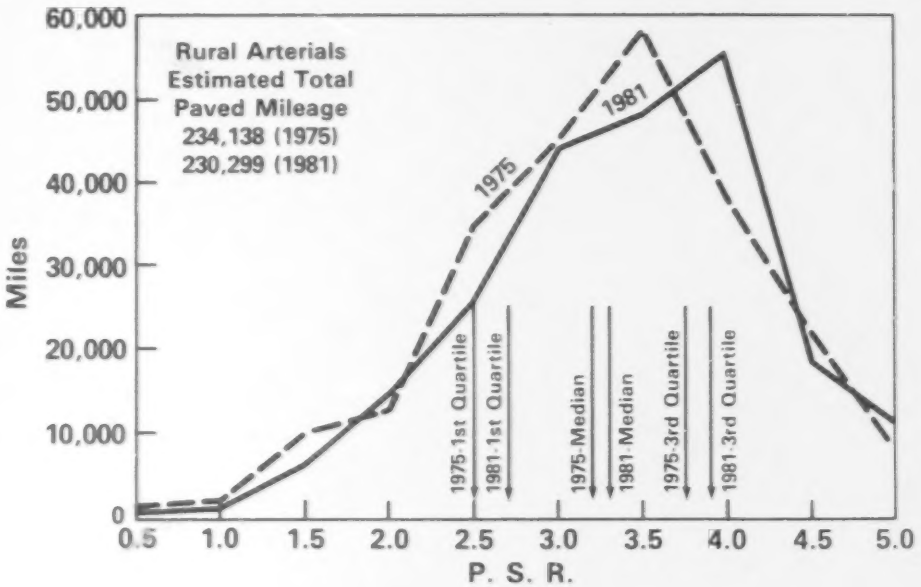


Figure III-13
Urban Arterial Pavement Condition Trends

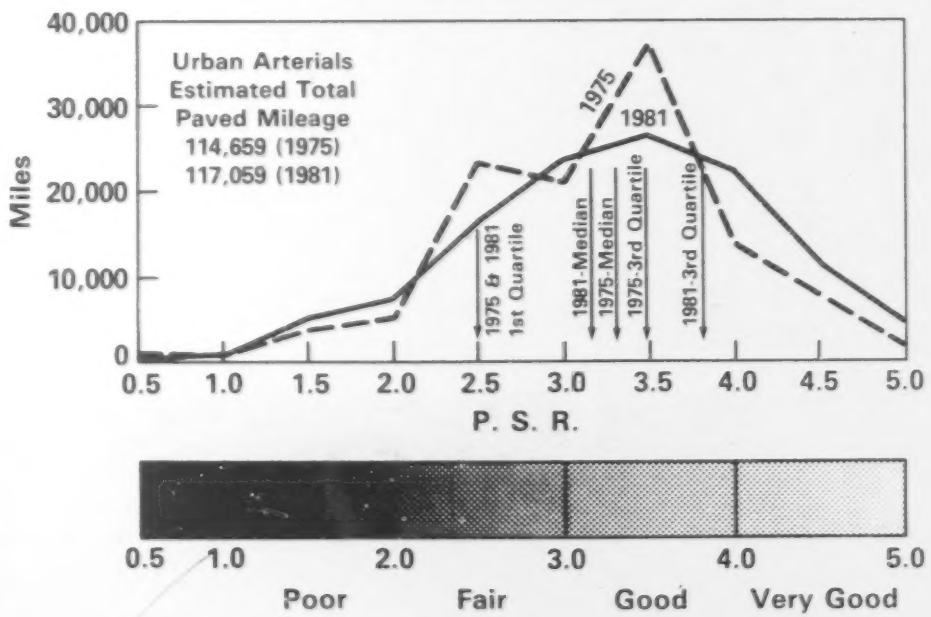


Figure III-14
Rural Collector Pavement Condition Trends

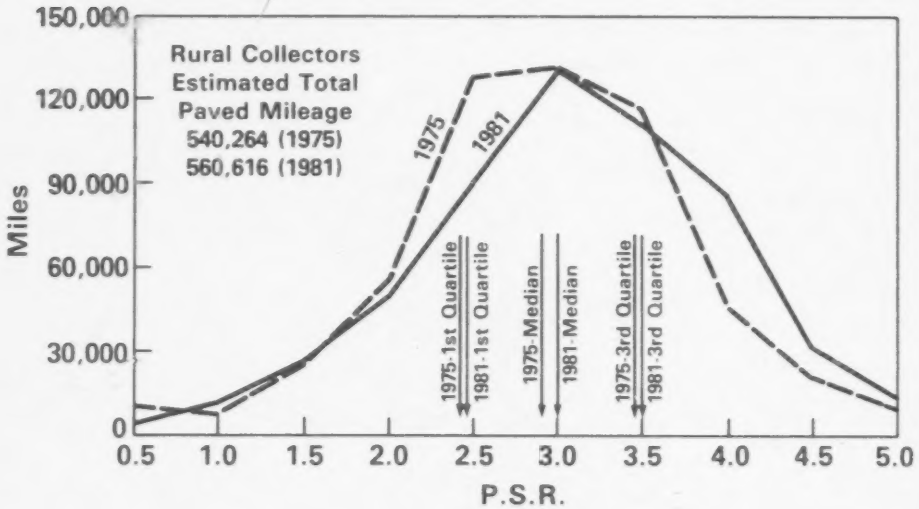


Figure III-15
Urban Collector Pavement Condition Trends

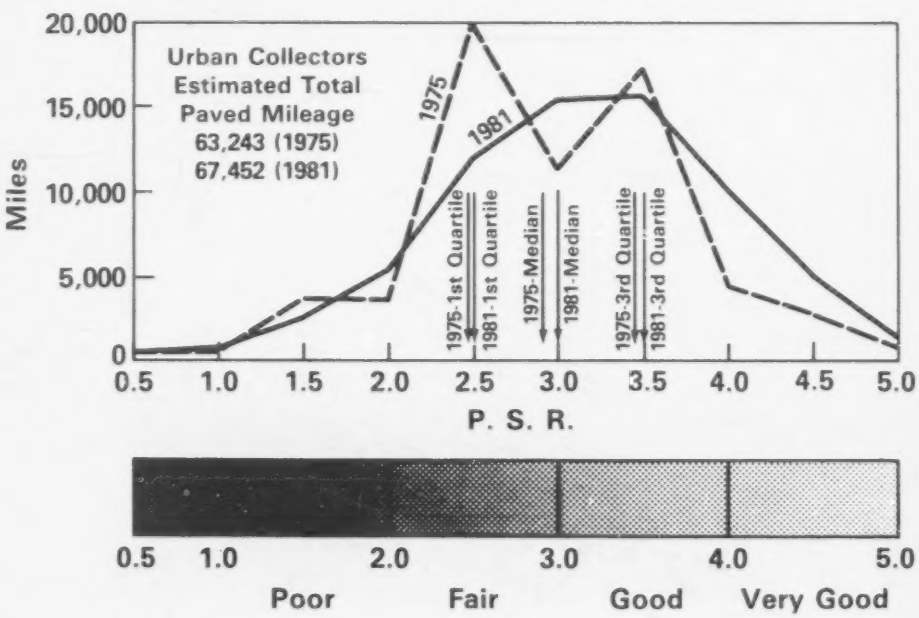


Figure III-16
Rural Congestion (V/C Greater Than 0.8)

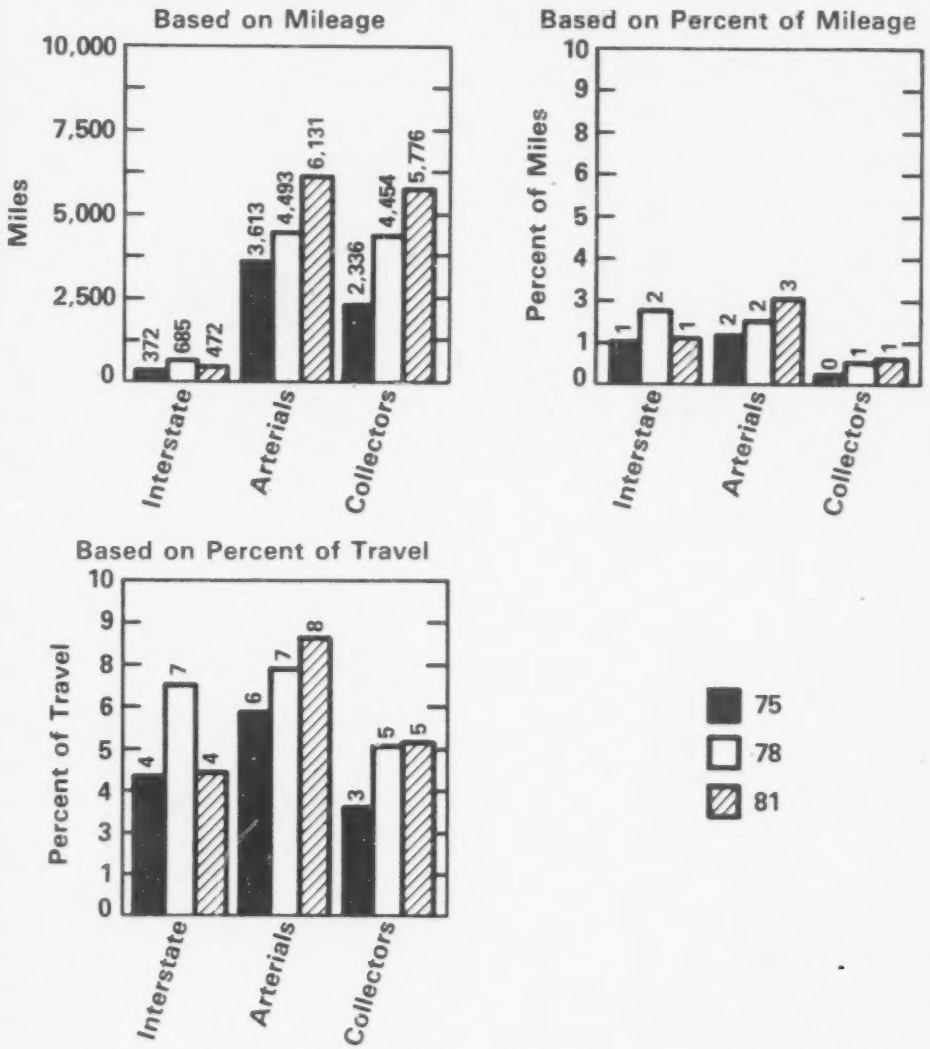


Figure III-17
Urban Congestion (V/C Greater Than 0.8)

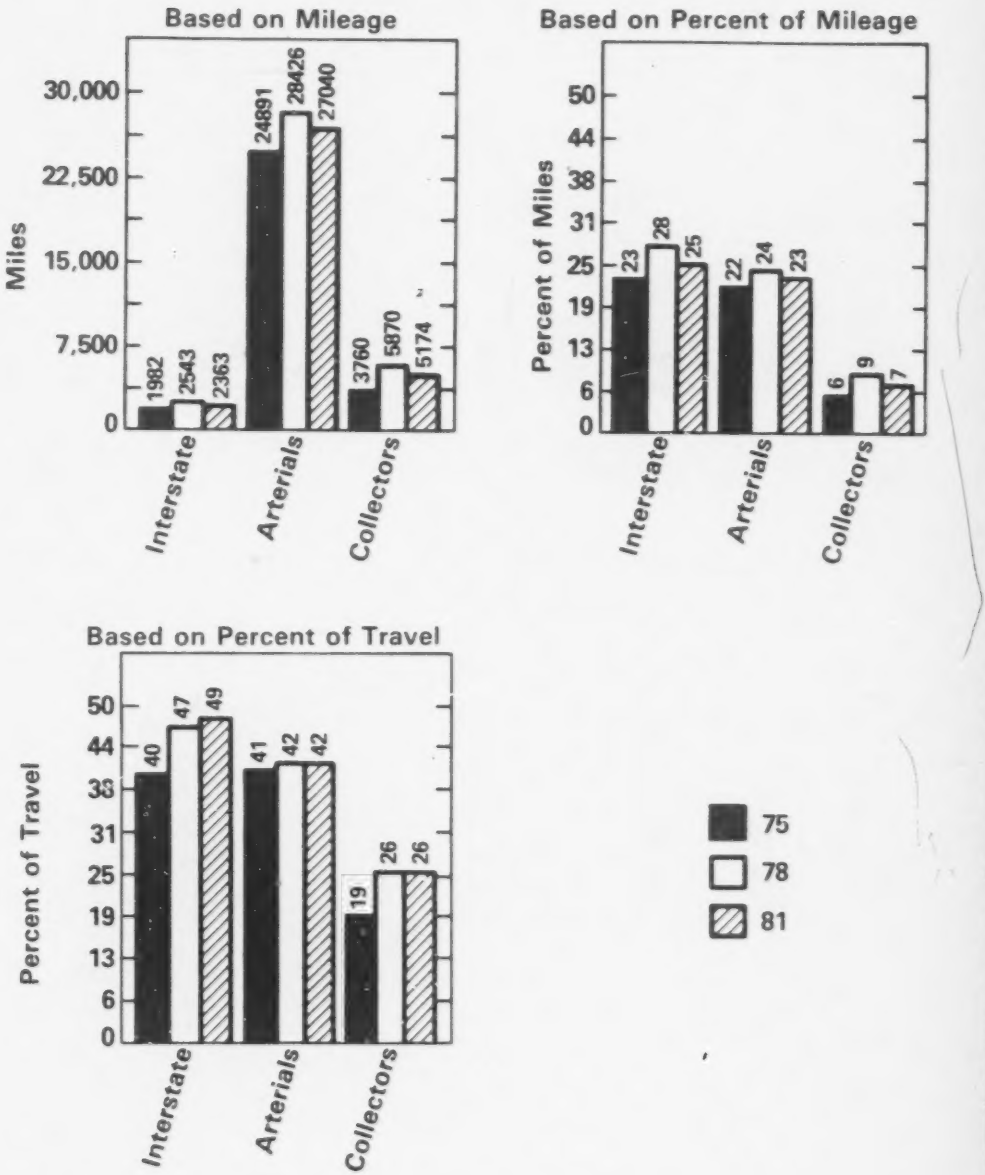
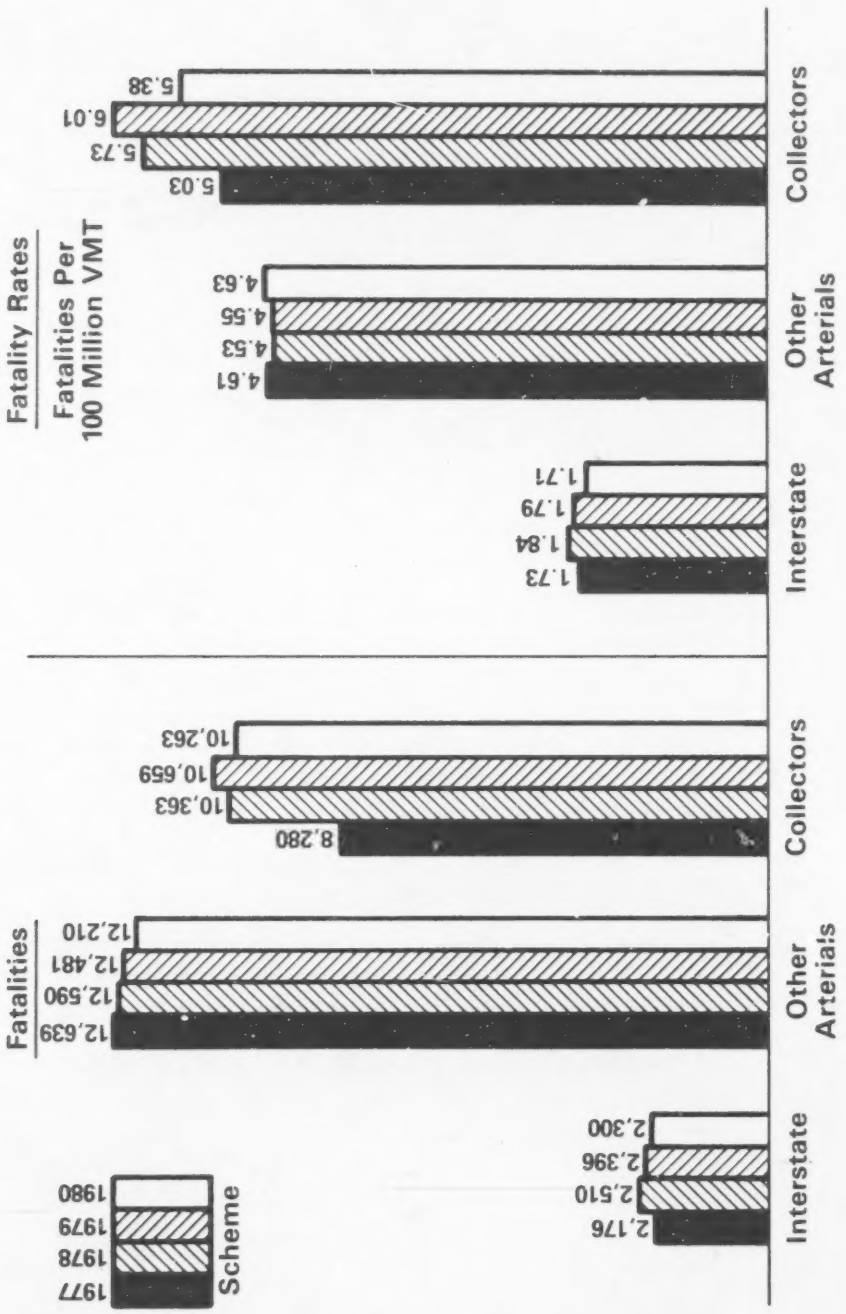


Figure III-18
Urban Highway Fatalities and Fatality Rates: 1977-1980

Figure III-19
Rural Highway Fatalities and Fatality Rates: 1977-1980



Chapter IV
HIGHWAY NEEDS: 1980-2000

The future condition and performance of the highway system is a function of travel demand and investment. Travel is expected to continue growing through the 1980's, although at a rate somewhat less than during the 1970's, and investments in highway capital improvements will combat the highway aging process.

The purposes of this chapter are to:

- o describe anticipated travel through the year 2000;
- o estimate the impacts of anticipated travel on future highway physical and operating conditions;
- o estimate the effects of several investment levels on highway conditions, including an assessment of full highway needs and the costs of maintaining current conditions;
- o describe highway conditions in the future if pre-1983 investment trends had continued; and
- o discuss the concept and effects of deferred capital costs.

ANTICIPATED TRAVEL

The 1981 report to Congress included a discussion of future highway travel, summarized from a report, Highway Travel: 1970-2000, prepared for the FHWA in 1981.[1/] The expectations for future travel contained in this report remain essentially unchanged from 1981.

Through the end of the century, personal travel is expected to grow for all modes, but at lower annual rates than in earlier decades. This will occur because energy used for travel in the forseeable future will continue to be petroleum based, and, even though fuel prices have stabilized in recent months, the real price of fuel has experienced unprecedented growth during the last decade. Even if there are no periodic shortages, as occurred in the 1970's, people will organize their travel habits, living and working arrangements, and vehicle purchase plans to take these costs into account.

Another factor expected to reduce the rate of growth of travel is the saturation effect. A very high proportion, over 70 percent, of persons of driving age (over 16 years old) already have an auto available to them. Consequently, auto ownership and use will probably not rise at the same rate as in the 1960's and 1970's. Even if there are only modest rates of economic growth through the 1980's, virtually all persons who need to or who are capable of driving will have a vehicle available for their use by the end of the decade.

1/ Referenced report is available from The National Technical Information Service, Springfield, Va. 22161, PB 81 183451

Rates of growth of travel are expected to continue decreasing for the remainder of the century. Auto travel is expected to grow at an annual rate of 2.4 percent until 1985, and van/pickup truck travel by 3.6 percent. These rates are below those experienced during the 1970's and earlier decades (3.0 and 10.0 percent). After 1985, auto travel is estimated to grow only 1.9 percent per year and van/pickup truck travel about 3.1 percent per year.

Average annual growth in passenger-miles of travel is expected to occur at a rate of 2.6 percent to 1985, lower than in previous decades, and to decline to 2.3 percent from 1985 to 2000. The percentage carried by each mode will change only slightly. The auto will remain dominant, as before, with 80 percent in 1980 and 78.9 percent in 1985, dropping to 75 percent by the year 2000.

Truck ton-miles of travel are expected to maintain a high average annual growth of 5.5 percent until 1985, after which annual growth rates will drop to 3.4 percent until the year 2000.

Overall growth in highway travel will approximate 2.34 percent annually through 2000, based on a "most likely" scenario of demographic and economic indicators that influence travel growth. In order to test the sensitivity of future highway conditions and needs to variations in travel demand, however, higher and lower estimates of travel demand are simulated in this chapter to provide a range of possible futures. These estimates are based on an examination of current trends in travel.

Methodology: Assessing VMT Impacts on the 1980 System

The first step in assessing future highway conditions is to apply estimated future year travel demand to the existing system to estimate impacts associated with the increased demand. Each highway section in the sample is analyzed during each year of the analysis cycle, in this case 1980-2000, comparing the physical, operating, and safety conditions to a set of specified minimum condition standards for each functional classification. The analysis identifies deficiencies anticipated in future years as well as backlog deficiencies carried over from previous years. Two assumed travel levels are tested to produce a range of results. For the analysis period, the high and low estimates are 2.8 percent and 2.0 percent annual growth in VMT. The range of forecasts has been reduced since the last report, but the "most likely" scenario remains well within the high and low estimates.

As each highway segment is considered, increments of travel demand are added to the segment, and measurements are derived for each of several physical and operating characteristics. For example, in analyzing the effects of increased travel on pavement condition, the segment under consideration is first identified by location, surface type, and pavement thickness. Each combination of these variables is associated with varying deterioration rates, depending on the traffic and vehicle mix applied. As the travel estimate is "loaded" onto the segment, the pavement deteriorates and is reported as a reduction in PSR. When the analysis cycle is completed, all study segments are aggregated and a national change in pavement condition is reported by functional system. Similar procedures are used to evaluate changes in other performance criteria. Appendix A provides detailed information on the procedures.

Changes in Highway Physical and Operating Conditions Associated with Future Travel

Figures IV-1 through IV-6 indicate the cumulative effects on pavement of anticipated highway travel for the period 1981-2000. These figures are not intended to suggest that the highway systems will actually appear as deteriorated in the year 2000 as the numbers imply. Capital investments will continue to be made through the years to mitigate the effects of aging, weather, and travel on the systems. These figures merely illustrate the extent of highway mileage that will become deficient through the year 2000.

They indicate that approximately 31,650 miles of rural and 9,070 of urban Interstate either currently are deficient or will pass the pavement minimum conditions standard and become deficient by the year 2000. Similar figures for arterials are 220,000 miles rural and 115,000 miles urban and, for collectors, 778,000 miles urban and rural combined.

Although deteriorating pavement is most visible, other deficiencies exist. In 1981, approximately 9,400 miles of Interstate, 215,000 miles of arterials, and 410,000 miles of collectors were deemed deficient from either a physical, operating, or safety perspective. Future investments will be made to correct these backlog deficiencies and to meet problems that will accrue in coming years.

THE COSTS OF MITIGATING HIGHWAY DETERIORATION

Capital investments are made to remove deficiencies due to travel, aging, and other factors. How closely future conditions parallel current conditions, as presented in the previous chapter, is an indication of how well capital investment strategies used by highway agencies are working.

Using the example of the rural Interstate System from Figure IV-1, highway capital investments designed to restore pavement serviceability are targeted at the full 31,650 miles of deficiencies, the total amount of Interstate that will require attention through the year 2000. If sufficient investment is made over the period to eliminate the deficiencies on the System, such an investment would be termed full needs for that particular system. This level of investment would result in a year 2000 System with no deficient pavement as defined in 1980.

The term "full needs" does not imply perfection. It means that, in the year 2000 no highway segment would exhibit physical, operating, or safety deficiencies below those currently deemed acceptable. Even under a full needs investment strategy there could and probably would be segments that have problems, but not sufficiently bad to be considered a deficiency. Tables III-13 and 14 (pp. III-24 and 25) indicate the minimum condition standards for various functional classes used in calculating needs.

Selection of minimum standards is an iterative process based on ongoing discussions with States. Investment requirement estimates for collectors included in this report are somewhat less than reported in the 1981 version because the pavement condition and operating speed standards have been relaxed, reflecting State practices.

Full highway needs, the sum total of investments required to eliminate all physical and operating deficiencies, is the upper bound of potential investment. Zero investment, of course, is the lower bound. Full needs and zero investment are included only to provide a range of possibilities since neither extreme is likely to occur.

Between the two extremes is a virtually limitless spectrum of investment possibilities, varying by investment level, program and improvement priority, standards applied, and investment timing. Variations in any of these can influence the dollar level of needs as well as future System conditions.

Calculation of Highway Investment Levels

The methodology for calculating full needs is explained in Appendix A. Tables IV-1 through IV-6 provide:

- o estimates of full needs through the year 2000 by system and improvement type, for two travel estimates (Tables IV-1 through IV-3), and
- o the costs of maintaining physical conditions as they existed in 1980, also for two travel estimates (Tables IV-4 through IV-6).

Full needs through 2000 are estimated at $456 billion (1980 dollars) assuming a 2.8 percent average annual VMT growth rate. The comparable estimate for a 2.0 percent average VMT growth is $427 billion. Although the increase in travel at the 2.8 percent growth rate is roughly 50 percent larger than that at 2.0 percent, total travel is only 17 percent larger. Therefore, full needs is not as sensitive to variations in travel demands, as might be expected. Variations in demand tend to redistribute needs by improvement type as shown in Tables IV-2 and IV-3. For example, the need for pavement reconstruction decreases, but the need for major widening increases.

Full needs implies a significant upgrading in overall conditions, primarily through improving roads to current design standards. Many miles of highway were constructed in the 1920's, 1930's, and 1940's, with few improvements made since except, perhaps, an occasional pavement overlay. When these roads were constructed, neither the performance characteristics of vehicles nor the technological capability of construction equipment permitted the design and construction of highways as they would be today. For this reason, improvement types associated with full needs tend to be capital intensive, with substantial amounts allocated for reconstruction and major widening improvements. Whereas in urban areas major widening is precipitated by capacity needs, the same type of improvements in rural areas tend to be created by geometric deficiencies, including inadequate sight distances, narrow lanes, and severe curves.

Tables IV-4 through IV-6 provide costs to maintain 1980 highway conditions in urban and rural areas by improvement type for two travel estimates. Urban cost to maintain varies from $109.9 billion for 2.0 percent travel to $130.7 billion for 2.8 percent average annual travel growth. The rural figures vary from $175.8 to $183.7 billion, for a total cost to maintain ranging from $285.7 to $314.4 billion. The urban costs are more sensitive to travel demand, hence the greater relative differences between high and low travel. Rural costs to maintain tend to be mileage sensitive rather than travel sensitive.

Cost to maintain implies that overall highway conditions will remain constant over time. Therefore, an investment equal to the cost of maintaining conditions will maintain the physical condition of highways, but not necessarily the performance characteristics. Note that even though an investment equal to the cost of maintaining conditions will stabilize overall conditions, the future mix of deficiencies will change. For example, the improvements in pavement conditions will be offset by increases in congestion, but the two effects will offset each other.

This is particularly true in urban areas where needed roadway widening to provide additional capacity is often constrained by inadequate rights-of-way. In this case, the cost of maintaining conditions is very close to full needs, with the implication that performance on urban highways will decline in future years regardless of the amount of investment. The needs presented for urban areas represent the maximum that can be invested in traditional highway improvements, given existing right-of-way constraints. Even at these investment levels, urban highway performance will decline. Additional urban transportation improvements must be realized by other means such as systems management, transit, flexible work hours, and a variety of other options.

Deferred Capital Costs

All needs estimates presented in this chapter assume that the degree of investment is limited by the availability of highway capital. Figure IV-7 illustrates the investment strategy implicit in that assumption. The dashed line plots cumulative investment required to maintain conditions through 2000 beginning with the 1980 highway capital program level and increasing at a constant rate through 2000. The curve is based on a capital program (not including Interstate cost-to-complete, local road expenditures, and certain bridge expenditures) of $7.5 billion in 1980 increasing to $23.1 billion in 2000.

The solid curve represents cumulative investments made as the needs occur; that is, the backlog discussed earlier in this chapter would be addressed early in the simulation rather than being postponed until additional capital is available in future years. Considering the present level and nature of highway financing it is unlikely that such extensive dollar requirements as suggested by the solid curve either could or would be met in the short-term. It is more likely that needed improvements would either be postponed until such time as funding was available or the need more critical, or else the improvement would simply not be made. The dashed line reflects that situation.

As indicated in Figure III-3, highways age over time due to travel wear and tear and weathering. If investment needs are postponed in the short-term and carried over as deficiencies in future years, the eventual cost of improvement reflects additional road deterioration. The two lines in Figure IV-7 cross at the breakeven point and diverge to 2000. The difference of $6.5 billion between the cumulative totals is the cost of deferring needed improvements. This difference represents the additional reconstruction cost for 8,400 miles of highway. Although conditions warranted repair earlier, these were postponed for lack of capital. Ultimately, this compounded deficiencies and increased reconstruction costs.

These deferral costs are in constant 1980 dollars. Any inflation that might occur between the indication of a need and the actual investment would compound the deferral cost. Further, even though the total deferral cost is approximately 2 percent of the total cost of maintaining conditions through 2000, the cost per mile for deferral is substantial. If improvements had been made when needed, the cost per mile would have been $480,000. However, deferring the improvement has increased the cost to $1,254,000 per mile, almost a 160 percent increase on affected highways.

Other Highway Capital Investment Requirements

The investments described above are based on an evaluation of existing highway segments only and do not include the cost-to-complete the Interstate System. They also do not include investments for specific bridge rehabilitation and reconstruction costs. Needs associated with these improvements are separately estimated and reported to Congress in an annual report on the Highway Bridge Replacement and Rehabilitation Program. The most recent of these estimates are discussed below.

Interstate Completion

As of December 31, 1981, 40,529 miles of the authorized 42,500 miles of Interstate were open to traffic. The cost of completing the remainder is estimated as $37.75 billion in 1980 dollars ($36.3 billion in 1981 dollars as reported in the 1983 Interstate Cost Estimate). In addition, the 1981 Federal-Aid Highway Act removed from the completion estimate $14.9 billion in 1980 dollars ($13.3 billion in 1982 dollars) in Interstate work not considered essential to providing a minimum level of service. Such items might include environmental features considered important by the State or affected communities or major safety projects for which other funds are available.

Bridge Replacement and Rehabilitation

Table III-15 in the previous chapter summarized the current conditions on bridges as reported by the Third Annual Bridge Replacement and Rehabilitation Report submitted to Congress in March, 1982. This report estimated costs to replace or rehabilitate those bridges currently deficient and eligible for funding to be $47.6 billion as shown on Table IV-7. Additional bridge deficiencies include $8.8 billion of existing Interstate bridge deficiencies not eligible for the highway bridge replacement and rehabilitation program (and not included in the $47.6 billion estimate) and accruing bridge needs through the year 2000. Future deficiencies are expected to accrue at a rate of $2.3 billion per year. The total estimate of existing ($47.6 billion) plus accruing ($46.2 billion) plus Interstate needs not otherwise included ($8.8 billion) is $102.6 billion.

Table IV-1
Estimated Capital Investments for 1981-2000 to Remove all Deficiencies (Full Needs) by Functional Classes[1/]
(In billions of 1980 dollars)

	URBAN						RURAL					
	Functional System						Functional System					
Travel Growth Percent Per Year	Interstate	Other Freeways and Expressways	Other Principal Arterials	Minor Arterials	Collectors	Total	Interstate	Other Principal Arterials	Minor Arterials	Major Collectors	Minor Collectors	Total
2.8	29.73	14.93	47.88	41.07	28.50	162.11	28.73	52.94	46.12	104.18	61.92	293.89
2.0	27.81	13.49	44.30	37.82	26.64	150.06	26.76	46.99	44.11	101.20	56.31	277.37

Total Urban and Rural

VMT	Urban	Rural	Total	Billion of dollars/year
2.8	162.11	293.89	456.00	22.8
2.0	150.06	277.37	427.43	21.4

1/ Excludes Interstate cost to complete, construction on new alignment and local road needs.

Table IV-2
Rural Highways (Full Needs 1981-2000)
(In millions of 1980 dollars)

	Interstate		Other Principal Arterials		Minor Arterials		Major Collectors		Minor Collectors	
Rate of growth of travel (percent per year)	2.0	2.8	2.0	2.8	2.0	2.8	2.0	2.8	2.0	2.8
1. Reconstruction to freeway standards	-0-	-0-	10,343	15,666	-0-	-0-	-0-	-0-	-0-	-0-
2. Reconstruction with added lanes	2,371	3,357	2,947	3,483	1,191	1,444	706	1,651	752	878
3. Reconstruction with wider lanes	364	294	2,722	2,656	4,411	4,385	16,200	17,870	10,969	11,476
4. Reconstruction as is	36	47	207	230	235	285	390	416	123	129
5. Isolated reconstruction	68	80	2,524	2,524	6,448	6,448	12,998	13,842	3,926	3,960
6. Major widening	4,074	6,350	5,275	5,772	4,498	6,127	2,381	3,263	162	332
7. Minor widening	679	464	2,228	2,130	1,224	1,293	4,026	4,389	2,788	3,446
8. Resurfacing with shoulder improvement	134	134	5,811	5,748	11,128	11,226	10,793	11,157	4,118	4,261
9. Resurfacing	13,218	13,282	9,206	9,320	6,430	6,426	7,930	7,741	4,330	4,228
10. Pavement reconstruction	5,820	4,718	5,728	5,412	8,545	8,485	45,778	43,853	31,140	33,206
Totals	26,764	28,726	46,991	52,941	44,110	46,119	101,202	104,182	58,308	61,916

Table IV-3
Urban Highways (Full Needs 1981-2000)
(In millions of 1980 dollars)

	Interstate		Other Freeways & Expressways		Other Principal Arterials		Minor Arterials		Collectors	
Rate of growth of travel (percent per year)	2.0	2.8	2.0	2.8	2.0	2.8	2.0	2.8	2.0	2.8
1. Reconstruction to freeway standards	370	374	1,510	1,802	-0-	-0-	-0-	-0-	-0-	-0-
2. Reconstruction with added lanes	5,143	5,239	363	465	942	1,057	686	729	-0-	80
3. Reconstruction with wider lanes	189	272	44	54	1,040	1,078	338	412	231	257
4. Reconstruction as is	980	1,306	241	345	853	996	298	340	112	126
5. Major widening (added lanes)	6,224	7,908	4,106	5,134	10,666	13,054	7,835	9,460	3,391	4,381
6. Minor widening	122	91	337	309	3,918	4,208	4,090	4,671	3,397	3,721
7. Resurfacing with shoulder improvement	1,072	1,106	1,488	1,470	3,301	3,201	5,458	5,336	7,807	7,727
8. Resurfacing	10,180	10,465	4,747	4,703	13,911	13,594	11,209	11,129	7,925	7,772
9. Pavement reconstruction	3,531	2,973	655	649	4,018	4,195	4,791	4,792	2,023	1,995
10. Traffic engineering	-0-	-0-	-0-	-0-	5,655	6,497	3,110	4,198	1,750	2,445
Totals	27,811	29,734	13,491	14,931	44,304	47,880	37,815	41,067	26,636	28,504

Table IV-4
Estimated Capital Investments for 1981-2000 to Maintain Conditions on Functional Classes[1/]
(In billions of 1980 dollars)

Travel Growth Percent Per Year	URBAN Functional System						RURAL Functional System					
	Interstate	Other Freeways and Expressways	Other Principal Arterials	Minor Arterials	Collectors	Total	Interstate	Other Principal Arterials	Minor Arterials	Major Collectors	Minor Collectors	Total
2.8	27.10	13.41	40.60	30.27	19.31	130.69	25.96	26.06	31.72	75.64	24.35	183.73
2.0	25.36	11.15	33.50	23.83	16.10	109.94	24.41	24.12	30.09	73.86	23.34	175.82

Total Urban and Rural

VMT	Urban	Rural	Total	Billion of dollars/year
2.8	130.69	183.73	314.42	15.7
2.0	109.94	175.82	285.76	14.3

1/ Excludes Interstate cost to complete, construction on new alignment and local road needs.

Table IV-5
Rural Highways (Cost to Maintain Conditions, 1981-2000)
(In millions of 1980 dollars)

	Interstate		Other Principal Arterials		Minor Arterials		Major Collectors		Minor Collectors	
Rate of growth of travel (percent per year)	2.0	2.8	2.0	2.8	2.0	2.8	2.0	2.8	2.0	2.8
1. Reconstruction to freeway standards	0-	-0-	5,438	8,133	-0-	-0-	-0-	-0-	-0-	-0-
2. Reconstruction with added lanes	2,162	3,011	468	678	769	1,728	809	1,466	848	1,011
3. Reconstruction with wider lanes	332	265	1,619	1,462	2,191	2,020	13,387	15,721	4,751	5,005
4. Reconstruction as is	36	47	168	210	84	115	337	223	101	101
5. Isolated reconstruction	68	80	327	388	2,271	2,378	8,320	8,904	1,040	1,103
6. Major widening	3,715	5,739	1,786	1,740	3,687	4,850	2,307	2,643	90	294
7. Minor widening	619	419	1,142	1,108	744	798	3,144	3,432	1,603	1,837
8. Resurfacing with shoulder improvement	134	134	3,541	3,498	7,251	7,368	8,716	8,971	2,799	2,973
9. Resurfacing	12,035	12,004	6,335	6,241	5,222	5,201	6,476	6,380	2,579	2,545
10. Pavement reconstruction	5,307	4,264	2,993	2,600	7,880	7,259	30,356	32,348	9,531	9,476
Totals	24,408	25,963	24,119	26,062	30,088	31,724	73,856	75,641	23,342	24,347

Table IV-6
Urban Highways (Cost to Maintain Conditions, 1981-2000)
(In millions of 1980 dollars)

	Interstate		Other Freeways & Expressways		Other Principal Arterials		Minor Arterials		Collectors	
Rate of growth of travel (percent per year)	2.0	2.8	2.0	2.8	2.0	2.8	2.0	2.8	2.0	2.8
1. Reconstruction to freeway standards	370	374	1,148	1,770	-0-	-0-	-0-	-0-	-0-	-0-
2. Reconstruction with more lanes	5,143	5,239	995	1,426	3,673	4,756	2,190	3,216	-0-	1,112
3. Reconstruction with wider lanes	189	272	193	267	1,628	1,605	351	632	730	868
4. Reconstruction as is	680	1,006	582	328	1,088	1,595	810	550	214	220
5. Major widening (added lanes)	5,574	7,077	2,332	3,579	5,733	8,804	2,721	4,585	1,069	1,551
6. Minor widening	122	91	168	183	2,738	3,174	3,307	3,951	1,669	2,292
7. Resurfacing with shoulder improvement	1,072	1,106	1,002	1,026	2,310	2,443	3,314	3,802	4,162	4,474
8. Resurfacing	9,180	9,465	3,752	3,947	9,386	9,752	7,005	7,933	4,803	4,857
9. Pavement reconstruction	3,031	2,473	982	885	4,133	4,761	2,768	3,479	2,460	2,656
10. Traffic engineering	-0-	-0-	-0-	-0-	2,814	3,706	1,367	2,124	997	1,283
Total	25,361	27,103	11,154	13,411	33,503	40,596	23,833	30,272	16,104	19,313

Table IV-7
Estimated Backlog Bridge Deficiencies
(In 1980 dollars)
(As of December 31, 1981)

System	Bridges Eligible for Replacement or Rehabilitation Sufficiency Rating 50	Estimated Replacement Cost in Billions	Bridges Eligible for Rehabilitation Sufficiency Rating 50 - 80	Estimated Rehabilitation Cost in Billions	Total Cost in Billions
Interstate[1/]	420	$ 0.4	2,724	$ 1.3	$ 1.7
Primary	7,911	5.8	12,046	4.1	9.9
Urban	3,626	4.3	4,323	2.0	6.3
Secondary	14,650	3.6	15,509	3.1	6.7
Total Federal-Aid	26,607	14.1	34,602	10.5	24.6
Off-system	121,618	18.8	50,692	4.2	23.0
Total[1/]	148,225	$ 32.9	85,294	$ 14.7	$ 47.6

1/ It has also been estimated that at the same time another $8.8 billion in Interstate 3R/4R bridge needs existed which were not eligible for HBRRP funds, for example: deteriorating bridge deck surfaces.

Table IV-8
Estimated Annual Accruing Bridge Deficiencies[1/]
(In 1980 dollars)

	Bridges Eligible for Replacement	Estimated Replacement Cost in Billions	Bridges Eligible for Rehabilitation	Estimated Rehabilitation Cost in Billions	Total Cost Billions
Interstate	270	$ 0.285	196	$ 0.084	$0.370
Primary	592	0.476	476	0.196	0.672
Urban	418	0.475	437	0.209	0.684
Secondary	535	0.153	553	0.120	0.273
Total Federal-Aid	1,815	$ 1.389	1,662	$ 0.609	$1.999
Off-system	1,581	0.245	790	0.066	0.311
Total	3,396	$ 1.634	2,452	$ 0.675	$2.310

The total bridge needs 1981-2000 is $102.6 billion, the sum of backlog and accruing needs plus the $8.8 billion ineligible deficiencies.

1/ Based upon a linear regression analysis of the past few years of national bridge inventory data and assuming bridge funds will be available in the same amounts as in previous years, an additional 3,477 bridges on the Federal-aid system will become deficient and eligible for HBRRP funds each year. The current cost to replace or rehabilitate these additional deficient Federal-aid system bridges is an estimated $2.0 billion. However, the STAA of 1982 substantially increases funds available to meet these needs. The rapidly accruing needs of bridges on the primary system will demand a large portion of the available funds. The analysis indicates that an additional 592 bridges are expected to become structurally deficient and another 476 bridges are expected to become functionally obsolete on the primary next year. The current cost to replace or rehabilitate these primary system bridges is an estimated $672 million.

Figure IV-1
Estimated Rural Interstate Pavement Requiring Capital Improvement Through 2000*

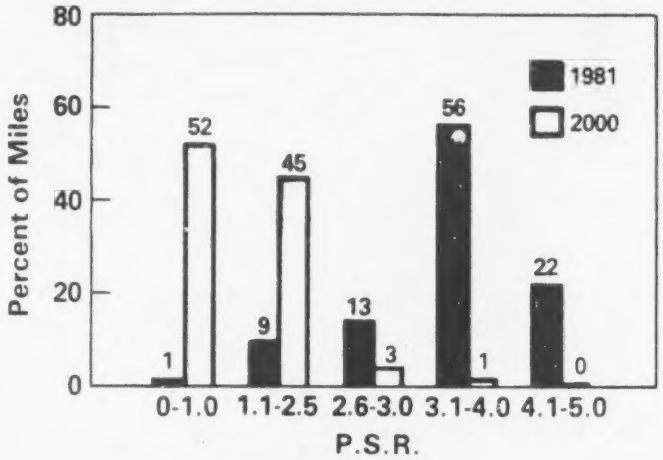
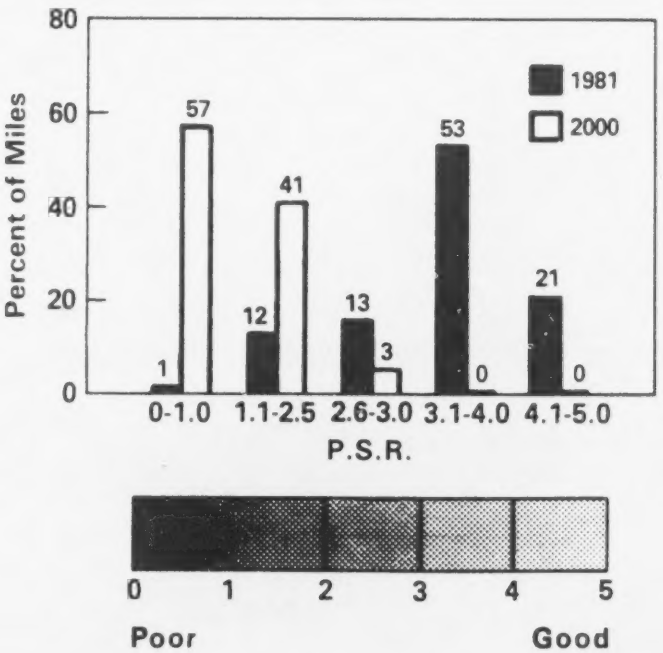


Figure IV-2
Estimated Urban Interstate Pavement Requiring Capital Improvement Through 2000*



*Pavement that reaches P.S.R. of 2.5 requires resurfacing.

Figure IV-3

Estimated Rural Arterial Pavement Requiring Capital Improvement Through 2000*

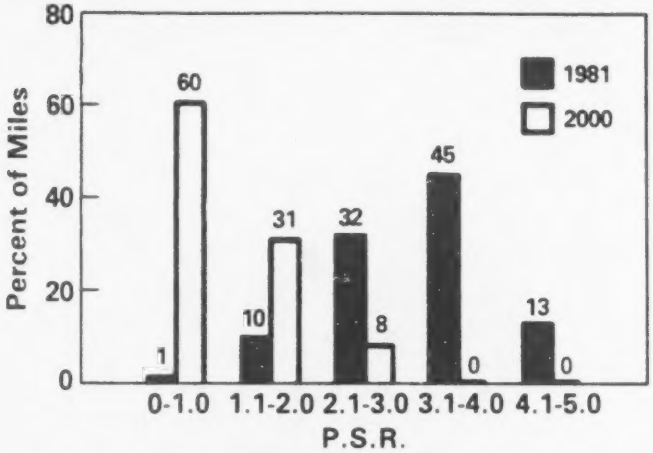
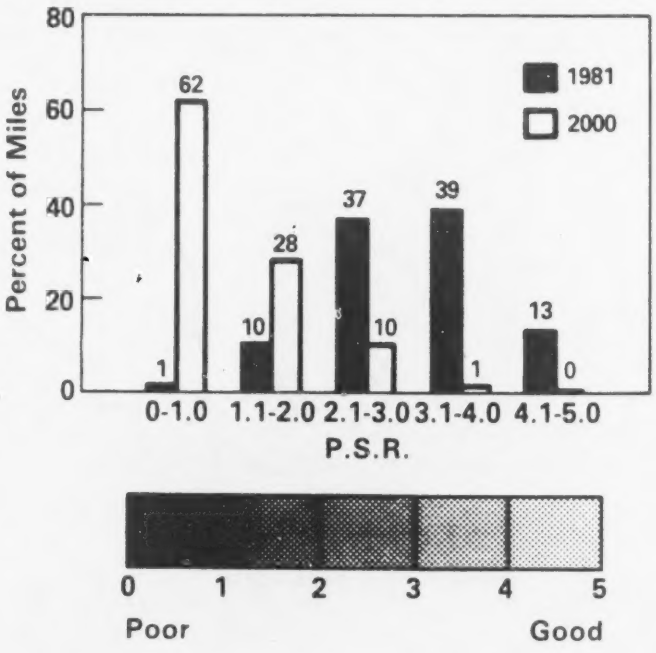


Figure IV-4

Estimated Urban Arterial Pavement Requiring Capital Improvement Through 2000*



*Pavement that reaches P.S.R. of 2.0 requires resurfacing.

Figure IV-5
Estimated Rural Collector Pavement Requiring Capital Improvement Through 2000*

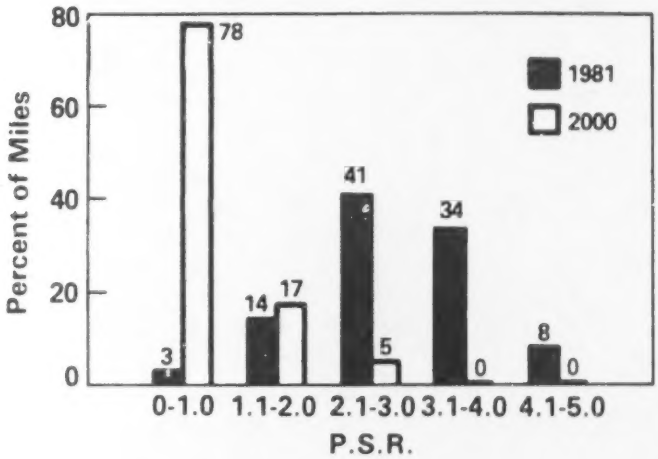
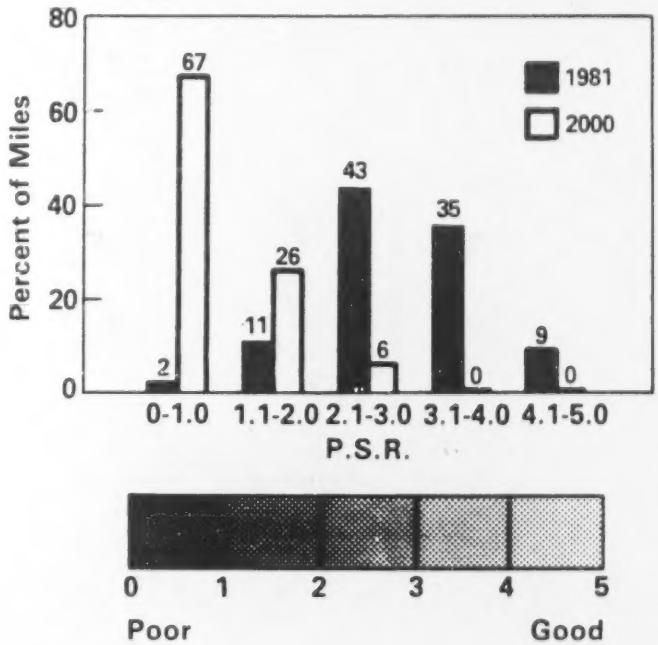
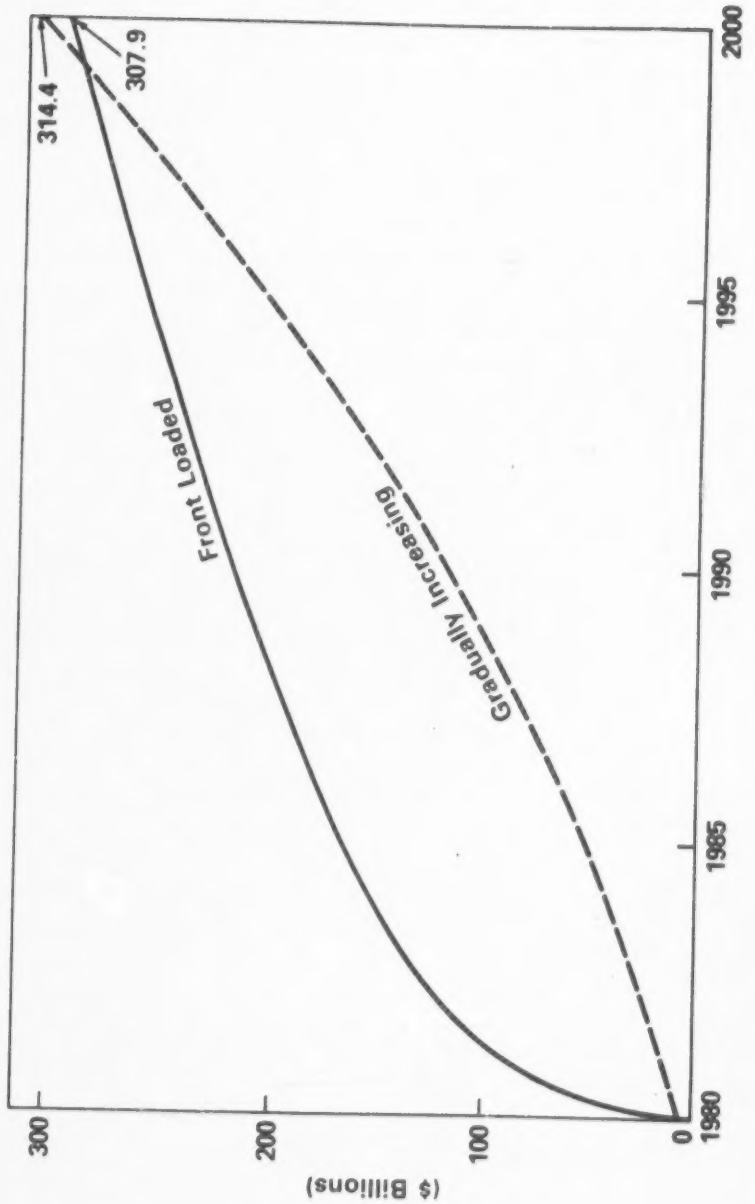


Figure IV-6
Estimated Urban Collector Pavement Requiring Capital Improvement Through 2000*



*Pavement that reaches P.S.R. of 2.0 Requires Resurfacing.

Figure IV-7
Cumulative Capital Investment to Maintain System Conditions
(1980 Dollars)



Chapter V
THE FEDERAL HIGHWAY PROGRAM

This chapter summarizes information on the condition and investment requirements of the Federal highway systems. The Federal-aid highway program consists of over 40 separate categorical areas of eligibility. However, funds are concentrated in six major programs--Interstate (including completion and 4R), primary, secondary, urban, and bridge. These six programs account for approximately 88 percent of the annual program authorizations. The material in this chapter addresses only those programs. Much of the information used here is taken from Chapters II, III, and IV of this report, and is organized to isolate the Federally funded elements of the highway functional systems.

There were approximately 828,500 miles of highways on the Federal-aid highway systems in 1981. This represented 69 percent of all nonlocal mileage in the country and about 21 percent of the 3.85 million miles of all public roads. In 1981, the combined Federal-aid systems carried slightly more than 96 percent of all travel on non-local highways and 83 percent of all highway travel in the country.

In this discussion of Federal-aid highway systems and Federal-aid highway programs, the material will be presented from the national perspective and, therefore, will tend to normalize system conditions, descriptions, and needs. Almost all highway mileage on the Federal-aid system is owned, operated, and maintained by the States or local jurisdictions. Goals, objectives, conditions, and needs vary widely among regions, States and localities. For example, northeastern roads are plentiful but are heavily used and aging rapidly. Population is also stabilizing in this section of the country. Their highway needs may be weighted heavily toward rehabilitation and restoration of the existing system.

In the southwest and the west, highways are somewhat limited, but much newer and used less frequently than in the northeast. These areas have experienced rapid population increases, and, therefore, highway needs in these regions may be directed toward added capacity or new access. The point is that the Federal-aid program must remain flexible enough for the recipients of the funds to provide adequately for their specific conditions and priorities.

Throughout this section, the discussion of program needs is keyed to an assumed base level of investment. The level chosen, in most instances, was one that would maintain overall highway physical conditions and performance as they were in 1980. The exceptions are: (a) the Interstate, where base funding levels could remove all present and future deficiencies, and (b) the Federal-Aid Urban System (FAUS), where travel conditions will probably deteriorate in the future if VMT continues to rise during peak periods (see Table S-2). This is anticipated because a large percentage of existing urban highway mileage can no longer be expanded to add new capacity.

THE PRIMARY PROGRAM

Description

The basis for the primary system was the Federal Highway Act of 1921. Provisions in the Act required that Federal-aid funds not only be spent on a designated system of interconnected roads, but also required that States designate these systems. Haphazard

road development was avoided by giving preference to projects, among the candidates for Federal-aid, that would complete an adequate and connected system of interstate highways.

Originally this system was not to exceed 7 percent of the total highway mileage for each State. When the Interstate was designated it was incorporated into the primary system as a subset. Congress realigned the primary system in 1976 to better reflect that interstate function.

Today the primary system consists of connected main highways important to interstate, statewide, and regional travel, consisting of approximately 256,000 miles, excluding the Interstate. Rural routes account for 227,000 miles (89 percent) with 28,600 miles (11 percent) of primary urban extensions.

Virtually all rural arterials and 30 percent of the urban arterials are on the primary system. The system links the Nation's cities and larger towns and farms in an integrated network that provides interstate and intercounty service. All urbanized areas (50,000 and over) and nearly all areas with populations of 25,000 are served by the system. Its importance is underscored by the fact that half of all highway travel in 1980 occurred on the primary system (including the Interstate System).

In rural areas, the typical primary route is a 2-lane highway with high-type pavement, lane widths exceeding 10 feet and shoulders of adequate width. The average route carries about 2,500 vehicles a day, with the percentage of trucks ranging from 10 to 30 percent.

In urban areas, the typical route expands to 4 to 6 lanes of high-type pavement that are undivided and without access control. The travel lanes are 12 feet wide with curbs in built-up areas and adequate paved shoulders in the outlying sections. Average daily travel is approximately 20,000 vehicles. During daily peak-travel periods the route is operating at full capacity.

System Condition

The typical route on the primary system has been built to a high standard and remains in good condition. However, much of the system still has significant deficiencies.

About 11 percent of rural primary mileage requires immediate replacement of its pavement, while another 32 percent has a PSR of 3.0 or less and will require replacement if improvements are not made in the near future. The percentage of rural primary mileage requiring immediate replacement has been fairly constant over the past decade. The share of mileage rapidly approaching that point has decreased in recent years, while mileage with a high PSR rating has increased. In the early 1970's, about half the rural primary mileage was in new or nearly new condition. That figure dropped to about 40 percent in 1978, but has stabilized since then.

As capital investments are made on a system, overall geometric characteristics improve gradually. The primary's geometric characteristics improved steadily through the mid-1970's, reflecting the type of capital improvements made to the system. In recent years the pace of improving geometry has slowed considerably, as 3R has accounted for a greater share of hard-pressed State capital programs.

Nevertheless, the primary system continues to receive higher type improvements than the lower-order systems and has significantly better geometric characteristics than the secondary system. This is reflected in the trends in fatality rates, which have decreased on the primary by an annual average of 1.3 percent since 1977.

Congestion is not a serious problem on the primary, but 8 percent of primary peak-period travel occurs under congested conditions. This is up from 6 percent in 1975. Approximately 20,000 primary bridges are considered deficient.

Primary System Needs

To offset further deterioration and to keep the overall performance of the primary system at the 1980 level will require a total 20-year investment of approximately $91.6 billion (1980 dollars) based on an anticipated 2.8 percent annual increase in VMT or $82.4 billion based on a 2.0 percent annual increase in VMT. This represents an average annual investment of $4.6 billion, or $4.1 billion which is roughly three times what the combined Federal and State expenditures were for the system in 1982 (see Table S-2).

THE INTERSTATE PROGRAM

Description

On June 29, 1956, President Dwight Eisenhower signed into law the 1956 Federal-Aid Highway Act which marked the beginning of the Interstate highway program. The intent was to develop a system of limited access highways constructed to uniform design standards, linking metropolitan areas and industrial centers of 50,000 or more population. The System was designed to meet Federal interests in national defense and interstate commerce, and was to connect at suitable border points with routes of continental importance in Canada and Mexico.

The System was originally expected to cost $27 billion in 1956 dollars and was to be completed simultaneously in all the States. The System is now 97 percent complete, though some important intercity gaps remain to be built, and many portions of the System open to traffic still need improvements. These run the gamut from major improvements such as control of access and construction of additional lanes, to minor work, such as signing and other final phases of completion.

The Federal share of eligible project costs is 90 percent, except in States containing large areas of public lands, in which case the Federal share may be higher. Funds are authorized to be apportioned annually to States based on their relative share of the estimated cost necessary to complete the Interstate System.

Recent priorities for the Interstate System stress expedited completion and preservation. The cost-to-complete the System was reduced by nearly $14 billion by the provisions of the Federal-Aid Highway Act of 1981, which limited costs "... to the construction necessary to provide a minimum level of acceptable service on the Interstate System which shall consist of: (1) full access control; (2) a pavement design to accommodate the types and volumes of traffic anticipated for the 20-year period from date of authorization of the initial basic construction contract; (3) essential environmental requirements . . . ."

The preservation of the System was established as a national priority in 1976 with the creation of the 3R program which provided for resurfacing, restoration and rehabilitation. Preservation was further advanced as a national priority in the 1981 Act, which nearly tripled authorizations, and established reconstruction as the fourth R.

System Condition

The Interstate System shows the highest pavement condition and the best safety performance among the Federal-aid systems. This is to be expected, since the Interstate has a higher share of recently constructed mileage than do the other Federal-aid systems. The Interstate also has higher design characteristics that enhance driver safety, e.g., wide lanes, paved shoulders, full access control, good vertical and horizontal alignment, etc.

However, pavement condition on the Interstate has been deteriorating. Ten percent of the mileage currently has a PSR of 2.5 or lower. Despite the completion of 3,659 new miles since 1975 (9.5 percent of the current System), most of which should be assumed to be in good condition today, mileage with a PSR over 4.0 decreased by 2,305 miles. The deterioration was more marked in rural areas, where the decrease was 2,297 miles, despite the addition of 3,021 new miles. In urban areas, 638 new miles of Interstate opened since 1975, but mileage with a PSR over 4.0 decreased by 8 miles (See Table III-9.)

The safety performance of the Interstate System has been more consistent, as measured by fatality rates. Fatalities per 100 million VMT were nearly constant from 1977 through 1980 (at or near 1.5 fatalities). The Interstate remains the safest highway system in the world.

Congestion on the urban Interstate continues to increase during peak periods. Added capacity since 1975 has not kept pace with increased peak-period demand. Over 48 percent of peak-period traffic on the urban Interstate experiences high volume/capacity ratios, compared to 47 percent in 1978 and 40 percent in 1975.

In sum, pavement condition on the Interstate continues to deteriorate, particularly in rural areas. Fatality rates have been nearly constant since 1977, while peak-period urban congestion has increased to affect nearly half the peak-period traffic it carries. Compared to other systems, though, the Interstate has the lowest share of deficient mileage and the lowest frequency of multiple deficiencies.

Interstate 4R Needs

Initially, the Interstate program placed all Interstate maintenance responsibilities on the States. This policy was altered by the enactment of a separate federally funded Interstate 3R program in 1976. The 3R program was originally authorized at $175 million annually for FY 1978 and FY 1979 and at $275 million annually for FY 1980 through FY 1982. Subsequent legislation in 1981 increased the authorization level to $800 million in FY 1983 and 1984 and expanded the program to include reconstruction. It also increased the Federal share from 75 percent to 90 percent.

Even with such a major commitment to preserving the System, the demand for these funds will far exceed their availability. Through 2000, approximately 40,000 miles of Interstate will require either resurfacing and rehabilitation or reconstruction. The cost of this work plus the work shifted from the Interstate construction program into the 4R program in accordance with the 1981 Act will require a total investment of $74.5 billion (1980 dollars) assuming 2.8 percent average annual growth in VMT. This would require a $3.7 billion average annual program in constant 1980 dollars. If travel grows at 2.0 percent per year, a total investment of $71.9 billion, or $3.6 billion annually will be required (see Table S-2).

THE BRIDGE PROGRAM

Description

The Surface Transportation Assistance Act of 1978 established the Highway Bridge Replacement and Rehabilitation Program (HBRRP) to aid the States in alleviating the recognized nationwide bridge problem. This program, the newest Federal-aid categorical segment, has greatly increased funding over a 4-year period. The program provides a fiscal incentive to States and local governments to prepare plans and advance bridge projects to construction.

The HBRRP is divided into two distinct categories: (1) apportioned funds distributed according to relative State needs, and (2) discretionary funds set aside for use by the Secretary of Transportation to replace or rehabilitate deficient, critically needed, high-cost bridges on the Federal-aid system. Under current authorizations, all but $200 million of the annual authorization is apportioned by formula.

For the most part, the administration of the apportioned funds is a continuation of an earlier program, the Special Bridge Replacement Program, with a minimum number of revised regulations to accommodate the expanded program.

System Condition

Bridge conditions, like those of a roadway, depend on a variety of physical and operating characteristics. These characteristics are combined to yield a "sufficiency rating". A rating below 50 indicates that a bridge is eligible for replacement or rehabilitation, while 50 to 80 indicates eligibility for rehabilitation.

Bridges, of course, behave differently than roadways. Bridges must support dead loads, live loads, and environmental loads in a different manner than those supported by a roadway. The rating quantifies a bridge's capacity to serve a highway system safely and efficiently. The major components of the rating are:

a. structural adequacy and safety - 55 percent.
b. serviceability and functional obsolescence - 30 percent
c. essentiality for public use - 15 percent

As noted in Chapter III, nearly half of the Nation's highway bridges have some type of deficiency (see Table III-15). The most common deficiencies are structural or geometric and occur most frequently on the lower-order systems (local and collectors) and least frequently on the Interstate System. For example, structurally deficient bridges account for 4 percent of the 46,400 Interstate bridges; 10.1 percent of the 116,000 bridges on other arterials; 16.4 percent of the 152,000 collector bridges; and 37 percent of the 240,000 local bridges.

As of December 31, 1981, 420 bridges on the Interstate had a rating below 50 (eligible for replacement or rehabilitation) and 2,724 rated from 50 to 80 (eligible for rehabilitation). Corresponding figures on the primary system were 7,911 and 12,046 bridges, 14,650 and 15,509 on the secondary system and 3,626 and 4,323 on the urban system. A total of 26,607 bridges on the Federal-aid system had ratings below 50 and 34,602 had ratings between 50 and 80.

A composite rating such as the sufficiency rating can mask the distribution of bridges approaching the point when improvements will be required. Any unmet needs will be compounded by newly developing needs. Table IV-7 shows the number of bridges on each

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Federal-aid system that have a rating below 50 and from 50 to 80. Table IV-8 summarizes the number of bridges that are expected to fall into these categories each year. Note that the annual increment is greatest on the Interstate System compared to backlog deficiencies (Table IV-7) since much of the System is still rather new and, therefore, a smaller percentage of bridges had reached the point where replacement or rehabilitation was required. Table IV-8, which was based upon a regression analysis of recent history, estimates annual increments in bridge needs under pre-1983 Federal funding levels.

Bridge Needs

Bridge backlog needs as of December 31,1981, and estimated accruing needs are included as Table IV-7 and Table IV-8.

URBAN PROGRAM

Description

The Federal-aid Highway Act of 1970 established the urban program to meet the unique transportation needs of the urban areas. It was established in an attempt to help alleviate traffic congestion, and to minimize the differences in characteristics between urban functional and Federal-aid systems.

The urban system consists of arterial and collector routes. It serves the heaviest urban population corridors, areas with populations of 5,000 or more, and major activity centers to aid in intracity movement. No route on the urban system is on another Federal-aid system, and each route connects with another route of the urban system or one of the other Federal-aid systems. The system is selected cooperatively by the appropriate local officials and the State highway departments. The system carries 44 percent of urban travel on 7 percent of all urban mileage.

The Federal share of eligible projects is 75 percent except in States containing large areas of public lands, where it may be higher. Authorized funds are annually apportioned to States based on their relative urban (defined as 5,000 or greater) population. No State receives less than one-half percent of the total.

Two-thirds of all nonlocal urban highway and street mileage is on the urban system. Minor arterials account for 45 percent of the system mileage, while collectors account for 38 percent. Principal arterials account for the remaining 17 percent, only 650 miles of which are expressways.

The majority (64 percent) of the mileage is in outlying sections of the urban areas, but travel on the system is divided evenly between center city and outlying areas. The typical urban system section is a 2-lane undivided roadway with 12-foot lanes. In the more developed sections of the urban area, the route has curbs instead of shoulders, typical of a city street. In the outlying areas, the roadway has a rural cross section with some sort of stabilizing treatment on 6-foot wide shoulders. The roadway has a high-type asphalt or concrete pavement and carries about 5,000 vehicles per day. The section is generally speed controlled at 35 m.p.h.

System Condition

Pavement on routes on the FAUS is typical of urban minor arterials and collectors. Currently 11 percent of the system has a PSR of 2.0 or lower. Twenty-nine percent of the bridges on the system have some deficiency. The majority of the deficient bridges on FAUS have deck geometry deficiencies.

Peak-period congestion is not a serious problem on the majority of FAUS routes. Currently only 20 percent of the system is congested during the peaks, but the rate is rising. In 1975, only 15 percent of the urban arterials and collectors experienced peak-period congestion. This increase reflects the growth in auto travel in the past decade and the small amount of increase in lower system capacity over the same period.

Urban System Needs

Over 95 percent of the existing urban system mileage will require repaving or pavement reconstruction by 2000, and congestion will become a factor on approximately 25 percent of the routes during daily peak-travel periods. However, nearly 50 percent of the roads and streets on the system today cannot be widened for additional lanes due to adjacent development. On these facilities, only traffic engineering improvements and auto use management remain as steps that can be taken to reduce future growth in urban congestion.

Improvement costs on the Federal-aid urban system through 2000 are estimated to range from $46.4 billion to $57 billion, depending on travel growth, an average of between $2.3 billion and $2.9 billion per year before inflation. This estimate applies only to physical improvements on roads and streets currently included on the system. Because of the broad definition of system eligibility, system mileage could double if the States and localities elected to add all qualified routes (see Table S-2).

THE SECONDARY PROGRAM

Description

The secondary program was established in 1944. The secondary system originally consisted of farm-to-market routes, but because of very loosely defined criteria, it eventually included every type of rural road from the local access road to the highest order arterial. The only stipulation was that a secondary route could not be on the primary system.

In 1976 the system was realigned by direction of Congress so that only roads that functionally served as major rural collector routes would be eligible for inclusion on the system. Today the system includes over 400,000 of the 440,000 miles (91 percent) of the major rural collectors in the country. These routes, unlike the primary system, do not form an interconnected network of highways. Instead they are, as their functional title implies, collectors of travel funneling onto and off the State arterial network. Jurisdiction of the system is divided almost equally between the States and local governments.

Today the secondary system serves three major activities. First, the routes provide service to county seats not on an arterial route and to other traffic generators of equivalent intracounty importance, such as mining or agricultural areas, shipping points,

etc. Second, they link major county traffic generators with nearby larger towns or cities. Finally, they serve the more important intracounty travel corridors and connect with routes of higher classifications within the county.

The roads on the secondary system comprise 40 percent of all rural mileage and carry 24 percent of rural travel. Typically, the secondary route (secondary system routes vary considerably by individual State and region of the country) is a 2-lane rural road paved with an intermediate type of surface treatment not designed to carry very heavy axle loads. The pavement itself is in fair condition. Each lane is 10 feet wide, and 4-foot wide earth shoulders complete the roadway cross section. The horizontal and vertical alignment of the roadway is adequate for the 600-vehicle-per-day density of usage. One bridge in three has some deficiency.

System Condition

Of all rural highways eligible for Federal-aid highway funds, the secondary system is in the poorest condition. Total capital investment has declined in real terms, and the available capital funds have been spread more thinly across the system.

Eighty-seven percent (350,000 miles) of the secondary system is paved. Fifteen percent has a PSR of 2.0 or lower and another 34 percent soon will require new pavement. Only 18 percent of the paved mileage has a PSR of over 4.0, which indicates new or nearly new pavement. No other Federal-aid system has such a low percentage of new or nearly new pavement.

Thirty-three percent of all bridges on the system have at least one deficiency. This is an increase from 1975 when 26 percent of the bridges were deficient. By far the most common deficiency is related to deck geometry--deck widths are narrower than the connecting highway sections.

Over 40 percent of the secondary system has deficient geometric characteristics, e.g., narrow lanes and inadequate horizontal or vertical alignment. Of the 400,000 miles on the system, 164,000 miles have one deficiency, and 115,000 miles have more than one deficiency.

The geometric and multiple deficiencies are reflected in the secondary system's fatality rates (fatalities per 100 million VMT). The rate has been very stable, at around 5.65, since 1976 (when the Federal-aid systems were realigned according to functional classification). This compares to 1.5 on the Interstate and 3.3 on the primary and urban systems, combined.

Secondary System Needs

The estimated cost of offsetting the effects of future VMT on the secondary system during the next 20 years ranges from $69.2 billion (1980 dollars), or an average of $3.5 billion per year before inflation, to $75.3 billion, an annual average of $3.8 billion. This level of investment would provide sufficient funds to maintain overall conditions as they existed on the secondary system in 1980. To remove all existing and anticipated deficiencies would cost an estimated $104 billion, or almost $5 billion annually (see Table S-2).

IMPACT OF THE STAA OF 1982

The passage of the STAA of 1982, which increased the Federal fuel tax to 9 cents per gallon, marked a significant increase in Federal capital investment on the Nation's highway systems, an interest that had waned gradually over time due to the fixed 4 cent Federal gas tax and highway-use fees, and the inflationary nature of the 1970's economy. This tax increase will produce an additional $4.4 billion per year in highway revenues. The years 1983 through 1986 should produce several significant changes in highway financing trends that have developed since 1970. Federal highway revenues, as a percent of total collections for highway purposes by all levels of government, should reverse their downward trend of the past 20 years. Overall growth in highway capital investment will accelerate compared to past growth rates. And, again at the Federal level, the percentage of revenues financing highway improvements that is derived from user charges is expected to increase.

The STAA will provide sufficient funds to complete the Interstate System in the early 1900's, meet all Interstate 4R pavement needs and most capacity needs, and provide assistance to States in meeting redefined Interstate needs. It will also provide sufficient Federal aid to maintain conditions on the primary system, assuming States approximate their historic share of primary capital investment. These two systems fulfill the requirements generally held to represent the highest priority for a Federal interest, such as density of travel, interstate commerce, regional connectivity, and defense preparedness. The STAA of 1982 also substantially increases Federal funding for the repair or replacement of deficient bridges and provides a moderate level of funding for the urban and secondary systems. Table S-3 compares anticipated total and annual capital investment by all levels of government with total and annual system needs through 2000.

Chapter VI
HIGHWAYS AND THE NATIONAL ECONOMY

The Federal, State, and local financial commitments to highway construction and repair are declining in relation to other public expenditures.[1/] They are, nonetheless, substantial in absolute terms. In 1981, over $41 billion, or approximately $180 per capita, were invested in highway construction and maintenance by all units of government. The expenditure of those funds had, and continue to have, two effects on the Nation's economy. First, the direct expenditure of public and private funds for the construction, maintenance, and operation of the system and for the purchase of vehicles to use on the system affects several production sectors, construction, employment, and the gross national product (GNP). Second, and perhaps more important, highway investment supports a certain level of highway performance, and that level of performance directly influences the cost of using the system. This chapter examines the economic aspects of highway transportation and discusses the likely economic impacts of changes in highway performance.[2/]

The economic significance of direct expenditures for transportation, and the highway system in particular, can best be illustrated by considering five points: (1) the Nation's annual transportation bill; (2) employment and earnings in the transportation and transportation related fields; (3) private expenditures for highway improvements; (4) highway taxation; and (5) highway consumption of other producers' outputs.

THE NATION'S TRANSPORTATION BILL

The ratio of the total transportation bill to GNP has been fairly constant over time. In 1980, the total transportation bill was $564 billion, the equivalent of 21.5 percent of the GNP. Highway transportation cost $448 billion (17.0 percent of GNP). The freight component of the total transportation bill was $205 billion, the equivalent of 7.8 percent of GNP. Highways accounted for $149 billion (5.7 percent of GNP) of this. The highway-related freight share has increased slightly from 67 percent of total freight in 1960 to 72 percent in 1980.

EMPLOYMENT

Highway construction influences employment not only in the materials industry, but in other basic and service industries as well. The Bureau of Labor Statistics estimates that every $1 billion of Federal-aid highway capital investment creates over 32,000 jobs.

1/ As noted in earlier chapters, the observations in this report were made prior to the passage of the Surface Transportation Assistance Act of 1982. Thus, the additional highway revenues provided by the 5-cent equivalent user fee increase, and their expected significant impact on the condition of the Nation's highways, could not be reflected. See the Executive Summary for a discussion of the likely impacts.

2/ A comprehensive discussion is included in the Transportation Systems Center Report, Highways and the Economy.

These include on-site construction and subcontractor work, contractor home office employees, and workers producing construction materials and equipment. Induced jobs, employment created by the spending of wages and profits, would substantially increase the employment total, although no agreement exists on the exact numbers.

Slightly fewer than 9 percent of all workers engaged in contract construction are employed in the highway construction sector. For 1980, assuming that State and local employment rates are the same as those for Federal-aid work, approximately 620,000 highway-related jobs were produced by the almost $20 billion in highway capital work excluding induced employment. Also, 8.8 percent of total civilian employment was engaged in a highway construction related job, including service, production of highway equipment and vehicles, or related industrial and government functions.

This proportion of total employment has remained fairly constant over time, although the internal job mix has shifted from direct operators to more support personnel. Highway construction and operation is one of the largest employers in the country.

Not only are transportation workers numerous, they are also well paid. In 1979, transportation employees earned, on the average, close to $22,500, compared with $20,000 in manufacturing, $17,000 in finance, insurance and real estate, and $26,000 in communications.

PRIVATE INVESTMENT

In addition to public investments, private firms invest heavily in transportation in the form of terminal facilities and rolling stock. In 1975, $326 million, or 7.3 percent of total net private investment, was made in transportation equipment, over $200 million of that total for highway equipment. The transportation share has declined from a 1950 high of 9.7 percent of total net private investment, although the actual sums expended have increased. Transportation accounted for 16.7 percent of total expenditures for new plant and equipment made in 1980. Over 3 percent of total expenditures was for motor vehicles alone.

Two key indicators of highway construction activity are "construction put in place" and "construction contract awards." In 1979, the value of all new construction was $229 billion, or 9.7 percent of the GNP, as shown in Table VI-1, which traces the relationship of highway and other construction to the national economy. Only 5.2 percent of this construction total was highway and street construction which accounted for only 0.5 percent of GNP. Table VI-2 shows contract awards for both total construction and highway construction for the period 1967-1979. As both tables show, highway construction has increased at a much slower rate than total construction. All figures are in current dollars and do not reflect the influences of inflation. In current dollars, total construction and highway construction increased, respectively, by 193 percent and 39 percent over the 12-year period. In constant dollars this represented a real increase over 12 years of only 6 percent for total construction and a 44 percent decline for highway construction.

HIGHWAYS AND TAXATION

The transportation sector is a major tax contributor, providing $48 billion, or 13.5 percent of total Federal taxes in 1980. Although taxes from transportation have increased steadily over the past 30 years by about $1.35 billion per year, other taxes have increased faster, and the transportation share of total taxation has declined from a 1950 high of 23.1 percent to its current 13.5 percent. The greatest increase in tax receipts has come from those persons engaged in using or supplying equipment and vehicles to the system, rather than from excise taxes or corporate income and profit taxes.

In 1980, approximately $23.5 billion in State taxes were derived from the transportation sector, or 23.3 percent of the State total. Again, the trend shows a decline over time from a 1955 high of 40.5 percent. Total Federal and State transportation expenditures have increased annually to a 1978 level of $36.2 billion. Of that total, highways have received $30 billion, or 82.9 percent of total transportation outlays. The highway share of capital outlay has declined steadily since 1947, from a high of 89.3 percent of total transportation outlays.

HIGHWAYS AS A CONSUMER OF INDUSTRIAL OUTPUT

Besides the substantial employment base and investment that can be attributed to transportation directly, transportation is also an important user of U.S. industrial output. In this country, transportation consumes 75 percent of all rubber, 54 percent of refined petroleum, 67 percent of lead, 36 percent of zinc, 27 percent of cement, 24 percent of steel, 12 percent of copper, and 21 percent of aluminum. Approximately 43 percent of construction costs on Federal-aid projects, excluding right-of-way and engineering, are for materials acquisition. Major elements include aggregates (12.2 percent of total costs), steel (10.3 percent), portland cement (5.1 percent), and bitumens (4.9 percent). Together, these account for 75 percent of total materials cost in highway construction. Over the period 1967-1975, the last year for which complete data were available, highway construction consumed about 34 percent of all aggregates produced in this country, 3 percent of all steel mill products (but 18 percent of structural steel and 32 percent of steel reinforcing bars), 17 percent of portland cement, and 37 percent of bitumens.

HIGHWAY PERFORMANCE AND NATIONAL ECONOMIC INDICATORS

The preceding section described the nature and magnitude of highway construction and operations and demonstrated the widespread influence that highways have on several elements of the national economy. Government and industry experts concerned with future economic performance agree that highways will continue to play an important role in the economic structure of the Nation. Future highway travel is expected to increase at an average annual rate of 2.0 percent to 2.8 percent as discussed in Chapter IV, based on an analysis of such factors as size and composition of the average American household, anticipated vehicle purchases, price and availability of fuel, demographic shifts, changes in the structural composition of industry, and other relevant variables. Although this is

slightly less than the growth experienced in the 1970's, it nonetheless represents an increase of over 50 percent in the volume of travel that must be accommodated by the year 2000 on the Nation's highway systems.

Today, the Nation enjoys a relatively high level of service on its highways, primarily because the Interstate System, the highest travel-per-mile system, is relatively new in comparison to other systems, and because normal maintenance has, so far, been able to substantially mitigate the impacts of increased travel, declining investment, and normal highway wear. However, overall condition and performance of the highway system has been deteriorating concurrently with the decline in capital investment and the inflationary spiral of recent years. In addition, all highway systems, particularly the Interstate, are approaching the point where substantial infusions of capital, rather than simple maintenance, are necessary to maintain serviceability. These factors portend a future of continuing and increasing deterioration so long as the disparity between highway needs and investment exists. This anticipated decline in highway system performance will have profound effects on the economy and on the system's ability to execute its social and defense functions as well as it has in the past. Chapter IV indicated that it will take one and a half times as much capital investment through 2000 as was being invested prior to 1983 just to maintain the 1980 level of highway performance on non-local roads.

Anticipated highway deterioration based on projection of pre-1983 expenditure trends carries the following general implications for highway users:

1. Highway operating costs per unit of travel will increase and speeds will decline.
2. Unit vehicle operating costs will increase even if one assumes that all expenditures on highways are recovered through highway-user imposts.

The following are some of the direct implications for the Nation's economy that can be expected from the continuation of pre-1983 investment trends:

1. There will be a decline in labor and capital productivity and an associated decline in growth in the Nation's GNP.
2. A larger percent of GNP will be spent for highway travel and a smaller percent for nonhighway purposes (personal or government consumption, or investment in industry).
3. A larger percent of GNP will be spent to produce and support inventories, reducing personal or government consumption or investment in industry.
4. More petroleum will be required since deteriorated highways require greater automotive fuel consumption per vehicle mile of travel.
5. A less efficient distribution of economic (and societal) activities over the Nation's land area will result.

Methodology

The methodology by which the conclusions in this Chapter are drawn is graphically illustrated in Figure VI-1. The methodology uses impact data and relationships discussed in Chapter IV to determine changes in vehicle speeds and operating costs associated with varying investment levels and strategies and travel demand. A more comprehensive discussion of this methodology and the study results is included in the Highways and the Economy report previously referenced and available through the Transportation Systems Center (TSC) in Cambridge, Massachusetts.

Briefly, the translation of changes in highway operating costs and speeds to changes in the future economy were performed by using an econometric model and an input-output model. These models measure the current level and structure of economic activity and forecast future activity based on mathematical relationships between variables and on assumptions about future demographics, consumer behavior, changes in the productive sector, and other factors that influence economic growth.

For the purposes of this analysis, the Chase Econometric Association Incorporated standard macro forecast, referred to as M-2000, was used to identify macroeconomic effects of changes in highway investment and performance, implied as a continuation of pre-1983 real investment levels. Therefore, changes in highway performance can be traced as deviations from M-2000 values for key economic indicators by modifying inputs to the MACRO model and measuring the differences. These inputs include changes in highway expenditures, taxes, labor and capital productivity, depreciation, and inventory associated with a particular level of highway investment.

In addition to the macroeconomic changes that can be measured using MACRO, the "ripple" effect associated with changes in investment and highway performance can be measured by using a national input-output model. This type of model measures the purchases from and sales to any sector of the economy. Since highway performance implies a cost to users, and since highway transportation cost is a part of the total cost of goods or services, changes in highway performance can be traced through the economy as changes in purchases and sales within the economy and in final demand sectors.

Four future scenarios were simulated to determine a range of possible economic consequences of investment levels and strategies. These included:

- a Base Case, defined as the maintenance of current highway performance;
- a Low Investment Case, defined as the sum-total of all anticipated highway investment, based on an estimate of future highway travel and revenue, minus expected local road, bridge, and Interstate completion obligations (includes effects of State taxation policy changes through 1981, but not additional Federal revenues to be raised under the STAA of 1982);
- a Full Needs Case, the cost of eliminating all unacceptable highway deficiencies; and
- an Intermediate Case, a mid-point between the base case and low investment case.

Modifications to MACRO associated with these scenarios included revisions to tax revenue and expenditure patterns and changes in productivity and inventory.

Funding Sources

The three alternative highway expenditure scenarios mentioned above represent substantial increases or decreases from the levels of spending assumed for the Base Case. To obtain comprehensive estimates of the macroeconomic implications of these increases or decreases, it is necessary to account for the sources of funding as well as the spending changes themselves.

Historically, funding for highways has come from four sources:

1. user fees (including tolls and parking fees);
2. non-user taxes;
3. investment income from highway trust funds; and
4. bonding.

Adjustments in the percentages coming from each source were made as necessary to accommodate specific characteristics of the alternative scenarios. For the Full Needs Case, incremental funding above that required to maintain the existing performance level is assumed to come from user fees, non-user taxes, and bonding. No additional funding is drawn from investment income under the assumption that all the investment income currently available is dedicated to Base Case spending. The Low Investment Case assumes that all spending reductions are matched by reductions in user and non-user taxes. The following table identifies the sources of funding increments or decrements by alternative scenario.

	Full Needs Scenario	Low Investment Scenario
User Fees	65 percent	69 percent
Non-User Taxes	30 percent	30 percent
Bonding	5 percent	

Debt service on bond issues, calculated at a 3 percent real rate of interest, is assumed to be funded from both user and non-user taxes. The debt service share for each category is assumed to equal its share of tax financing at the State and local level.

Once the required revenue changes have been allocated to the broad funding categories, the next step is to identify the Federal, State, and local shares. In most cases, it is sufficient to distinguish between Federal and combined State and local. Only in the case of non-user taxes is the State and local share further disaggregated; this is done because the mix of taxes at the State level is quite different from that at the local level. The data on which the percentages by level of government are based are taken from Highway Statistics, FHWA.

The last stage is to apply the revenue changes to specific Federal, State, and local taxes and to associate these specific taxes with variables in the macro model. Revenue changes funded from non-user taxes are allocated among personal income taxes, corporate profits taxes, property taxes, and "other" taxes. The share designated for a particular tax at each level of government is equal to its share of "general tax revenue from own sources" net of highway-user taxes. The data on which these percentages are calculated are taken from the U.S. Bureau of Census, Governmental Finances. The tax burden assigned to local property taxes is divided between commercial/industrial owners and other owners to accommodate the specification of tax variables in the simulation model.

Productivity, Depreciation and Inventory Modifications

Productivity, depreciation, and inventory modifications for these MACRO variables are based on the impact assessments generated by the HPMS system. Figures VI-2 and

VI-3 illustrate the changes in vehicle operating cost and travel time associated with varying degrees of investment. The values A, B, and C reflect the changes from Base Case conditions of going to either a Low Investment, Intermediate, or Full Needs Case.

Macroeconomic Effects

The vehicle cost and travel changes, plus detailed data from several published sources, was used to develop dollar costs and other specific effects of different investment strategies. Major sources include: A study by Jack Faucett Associates Incorporated which contained input-output estimates for 13 highway modes; heavy truck operating costs from a study done by the TSC as part of the U.S. Department of Transportation Truck Size and Weight Study; statistics on ton-miles and value of goods shipped from the U.S. Department of Commerce Bureau of the Census Commodity Transportation Survey; and Gross Private Investment statistics from the official Department of Commerce, Bureau of Economic Analysis 1977, input-output tables.

Table VI-3 summarizes the macroeconomic results of the Base Case, Low Investment Case, and a intermediate case representing a long term increase in highway capital investment but less than the cost of maintaining performance. Figure VI-4 graphically depicts the relationship of highway capital investment to changes in GNP.

As reported in Chapter IV, Full Needs through 2000 are estimated at $456 billion, and at $296 billion for the period 1983-1995, the time frame for this macroeconomic analysis. An examination of Table VI-3 and Figure VI-4 indicates that any level of highway capital investment up to the base case through 1995 will increase GNP. These figures indicate that a positive relationship exists between highway investment and net economic gain. The figures do not imply a benefit-cost relationship, however, since some benefits of capital investment may be counted more than once.

Direct benefits of highway investment consist of a reduction in user inputs to the system, including travel time, enroute inventories, vehicle operating cost, vehicle depreciation, and accident costs. Indirect benefits such as increased property values, housing opportunities, or market position, may also be included in the calculation of net economic gain. These indirect benefits, with few exceptions, are the result of a transfer of the direct benefits of highway investment to non-users.

Were the savings in time or vehicle operating cost transferred in their entirety to consumers, indirect benefits could be accurately considered true benefits. As is generally the case, however, at least a share of user cost savings are retained rather than transferred and the separation of benefits becomes confused.

The use of GNP to reflect benefits may also understate the total effects of investment. Improved highway performance enhances personal mobility along with economic activity. Although the calculation of GNP assesses the economic implications, no consideration is given to user savings for commuting, recreation, or other types of non-business trips. In addition, highway investments benefit future users since improvements typically affect users throughout the project's design life.

For these reasons, Table VI-3 and Figure VI-4 should be interpreted only as expressions of the general economic effect of highway capital investment and not as a true benefit-cost analysis.

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Macroeconomic Impacts of Trend Investment

Table VI-3 indicates that the trend of pre-1983 capital investment projected through 1995 would equal approximately one-third of that required to maintain highway performance. In terms of highway performance, both the cost of operating a vehicle and the time required to travel over the system would increase due to future system deterioration. As performance declined from the 1980 service level, many trips would not be made that would otherwise be made if performance remained constant, because of increased cost and time requirements. That sensitivity to performance, known as demand-price elasticity, has been factored into the VMT and operating cost estimates using elasticities reported to Congress in the 1982 Highway Cost Allocation Study.

The macroeconomic simulation shows that maintaining 1980 performance would yield a cumulative $747.2 billion addition to GNP through 1995 or, put differently, that a continuation of pre-1983 investment levels would "cost" $747.2 billion in foregone GNP through 1995.

Table VI-3 also indicates that paid labor hours enroute would have to increase to provide the same level of highway service as in 1980 because of the decrease in vehicle speeds. That increase of 3.04 million labor hours represents 2.63 percent of the forecast 1995 labor force, or a 2.7 percent relative labor productivity decline.

Interindustry Effects

The decline in highway performance would affect not only aggregate economic indicators, but also industry-by-industry indicators. This would work in two ways. First, a comparative shortfall in performance would affect industries that supply highway construction activities and industries that sell to vehicular maintenance. Second, consumer purchases would decline for certain items, particularly luxury items, as more personal disposable income was consumed by vehicle maintenance and the increased cost of goods and services delivered by highways.

In the first instance, the decline in direct highway expenditures would cause a sharp comparative shortfall in the outputs of paving and asphalt, concrete and gypsum, stone and clay mining, and structural metal products industries, ranging from 17 percent to 38 percent in 1995. This would be expected since highway construction is such a significant purchaser of these products.

As performance declined, industries that produce motor vehicles, crude and refined petroleum, tires and inner tubes, and auto parts, would see an increase in output as vehicles require higher levels of maintenance and increased vehicle depreciation depleted vehicular stocks. Estimates of future output for these industries range from an increase of 0.4 percent to 15 percent.

In the second instance, consumer purchases would decline for products such as books, watches, drugs, photographic products, soft drinks, apparel, furniture, and appliances, along with other discretionary purchases as highway costs take a bigger bite out of disposable income.

It should be noted that the average American household in 1980 spent almost 20 percent of its net disposable income on maintaining and operating its personal vehicle fleet. That was only slightly less than it spent for food. Changes in highway performance have a potentially enormous impact on consumer buying habits.

Highway deterioration is a triple whammy when it comes to the economy. First, when highways conditions decline, GNP growth declines, and disposable income is related to GNP. Second, the cost of using the highway system becomes greater for the consumer, and that cost must be met with a smaller income. Third, the prices of basic commodities increase, and the purchase of these must be weighed against the desire or need to use the highway system regardless of condition or cost. Approximately 93 percent of all trips are by highway. Even marginal changes in highway performance are significant when reliance is of that magnitude.

Table VI-1
Construction Put in Place and Gross National Product

Year	All Construction ($ million)	% of GNP	Highway and Street Construction ($ million)	% of All Construction	% of GNP
1967	78,082	9.8	8,591	11.0	1.1
1968	87,093	10.0	9,321	10.7	1.1
1969	93,917	10.0	9,250	9.9	1.0
1970	94,855	9.7	9,981	10.5	1.0
1971	109,950	10.3	10,658	9.7	1.0
1972	124,085	10.6	10,429	8.4	0.9
1973	137,917	10.6	10,505	7.6	0.8
1974	139,501	9.8	12,065	8.7	0.9
1975*	134,535	8.8	10,854	8.1	0.7
1976*	151,054	8.9	9,743	6.5	0.6
1977*	173,975	9.2	9,380	5.4	0.5
1978*	205,457	9.7	10,712	5.2	0.5
1979*	228,950	9.7	11,915	5.2	0.5

***NOTE:** Data for highway and street construction are not directly comparable with data prior to 1975 due to a change in reporting procedures. Items no longer reported include office buildings owned by a State highway department and sewer and water construction done by a highway agency.

Source: Construction Review, U. S. Department of Commerce

Table VI-2
Value of Construction Contract Awards

Year	Total Construction ($ million)	Highway Construction ($ million)	Highway Construction as % of Total	Index of Construction Contract Award (1967=100) Total	Highway
1967	54,514	5,522	10.1	100.0	100.0
1968	61,732	5,305	8.6	113.2	96.1
1969	68,294	6,625	9.7	125.3	120.0
1970	68,294	6,520	9.6	125.3	118.1
1971	80,188	6,327	7.9	147.1	114.6
1972	90,979	6,505	7.2	166.9	117.8
1973	99,304	6,516	6.6	182.2	118.0
1974	93,685	7,313	7.8	171.9	132.4
1975	92,659	7,363	7.9	170.0	133.3
1976	110,061	6,205	5.6	201.9	112.4
1977	139,723	7,792	5.6	256.3	141.1
1978	159,930	9,141	5.7	293.4	165.5
1979	166,378	11,076	6.7	305.2	200.6

Source: Construction Review, U. S. Department of Commerce

Table VI-3
Macroeconomic Effects of Three Highway Investment Strategies, Through 1995

	Low Investment Case (Pre-1983) Trend	Intermediate	Base Case 1980 Service Level
Investment (Percent of Full Needs)	28.5	57.8	85.0
Vehicle Operating Cost/VMT (1980 dollars)	0.289	0.255	0.227
Increment (Index)	1.273	1.134	1.000
Time/100 VMT (Hours)	4:43	4:19	3:56
Increment (Index)	1.199	1.097	1.000
VMT (Billions)	1,969.0	2,172.0	2,428.0
Increment (Index)	0.811	0.895	1.000
VMT Annual Increases (Percent)	1.7	2.4	3.16
1995 GNP (Billions of 1980 dollars)	5,039.63	5,133.53	5,186.13
1980-1995 Cumulative GNP Increase (Billions of 1980 dollars)	-0-	489.50	747.20
1995 Paid Labor Hours Enroute (millions)	21.23	19.27	18.19
Percent of 1995 Labor Force	18.20	16.70	15.80
Change in Paid Labor Hours Enroute Compared to 1980 (millions)	3.04	1.08	-0-
Increase as Percent of 1995 Labor Force	2.63	0.94	-0-
Labor Productivity Increase Relative to 1980 (Percent)	-2.70	-0.99	-0-

Figure VI-1
Methodology for Estimating the Economic Impacts of Changes in Highway Performance

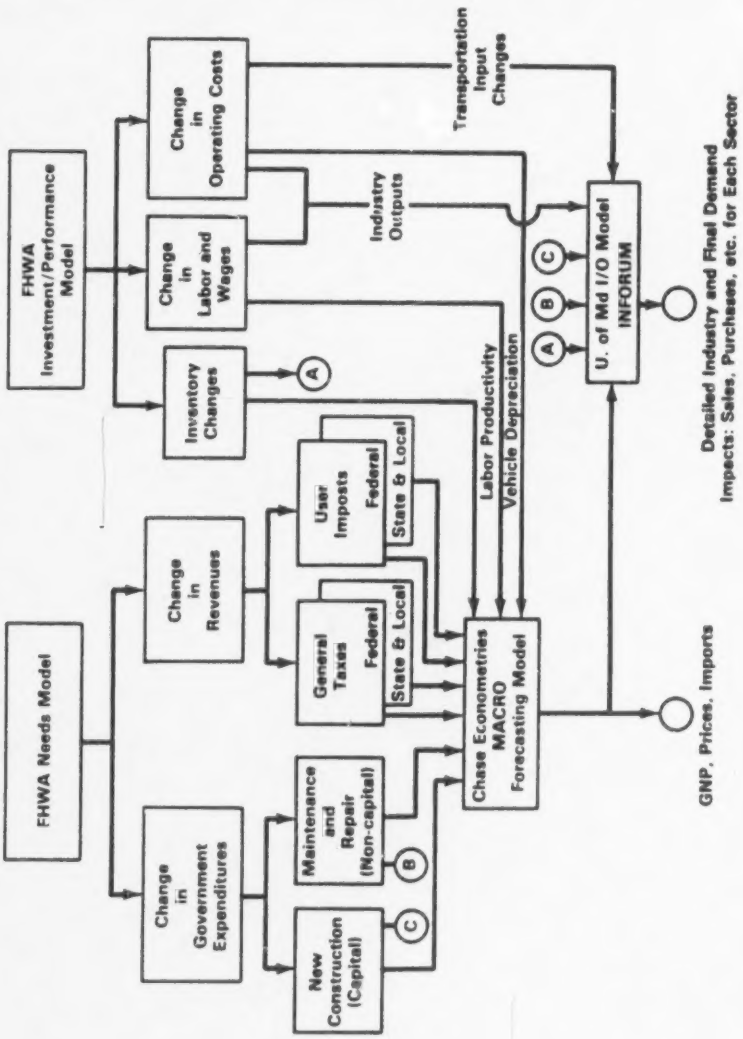


Figure VI-2
Impact of Alternate Investment Levels on Cost of Vehicle Operation

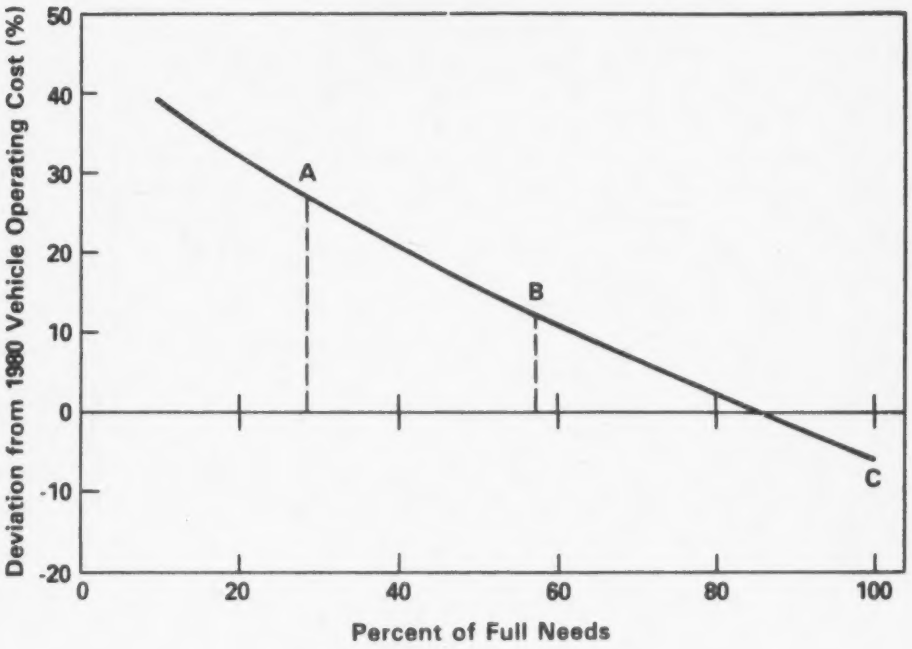


Figure VI-3
Impact of Alternate Investment Levels on Traveltime
(All Vehicles)

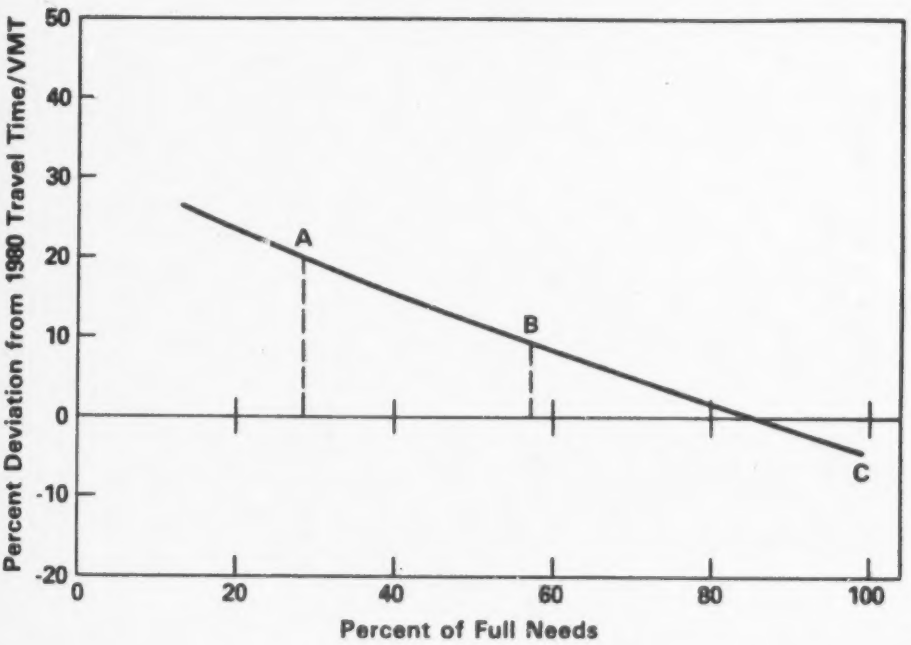
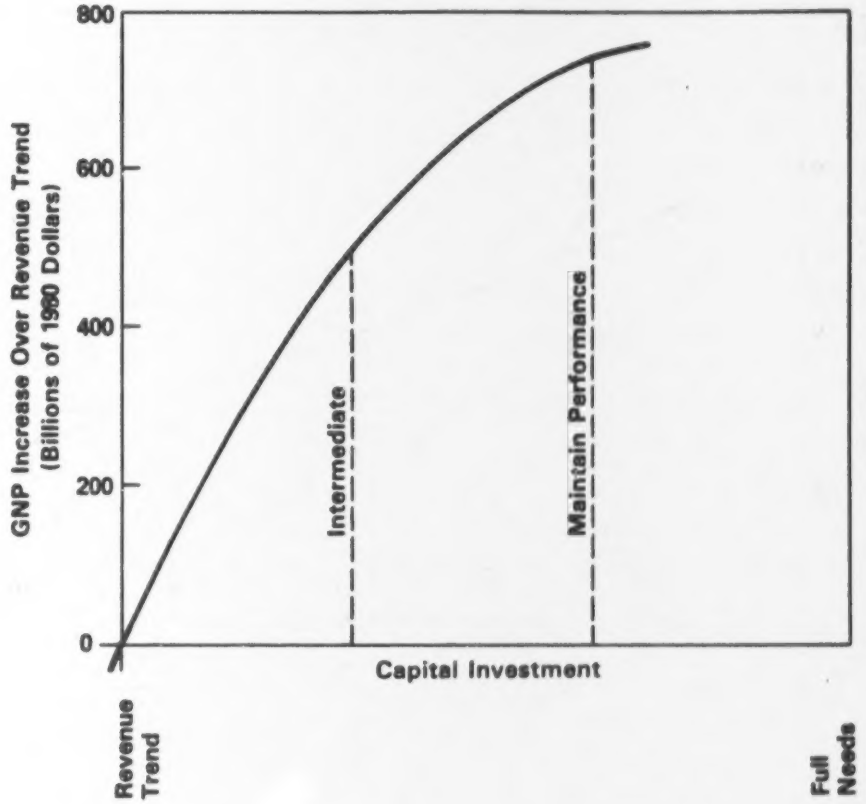


Figure VI-4
Macroeconomic Effects of Highway Capital Investment Over the Revenue Trend



APPENDIX A
ESTIMATING THE IMPACTS OF CHANGING HIGHWAY CONDITIONS

BACKGROUND

Over the past 8 years, as a part of the Highway Performance Monitoring System (HPMS), the Federal Highway Administration (FHWA) has been developing an analytical package (series of computer models) designed to (1) estimate future highway needs, (2) test the sensitivity of highway needs to repaving and reconstruction policies, the makeup of the vehicle fleet, future travel, and future investment levels, (3) determine the relationship between future highway investment and future highway performance, and (4) assess the benefits and costs associated with various future functional system and improvement type investments. The output from these models is used by the U. S. Department of Transportation and the U. S. Congress in the development of highway programs and policy. Although the models were developed to provide information at the national level, the States have program concerns similar to those of the FHWA. For this reason, the models are being modified to provide State highway agencies with the same capability to test their own State highway program options as is currently available at the Federal level. The purpose of this paper is to describe the operation of these simulation models and to illustrate how they are used to measure the changes in highway conditions and performance resulting from future highway investments.

INPUT

Basic input to the analytical package are inventory data consisting of a limited number of data elements for each section in a statistically designed, small sample of highway sections. These samples (three percent of statewide mileage) are expanded to represent the arterial and collector highway systems in rural, small urban, and urbanized areas of each State. Specific physical condition, operational, accident, and capital improvement data for the highway sections sampled are reported annually by the States as a part of the HPMS (1). Table I contains a list of the data, reported annually by the States for the sample sections, that are used by the models.

METHODOLOGY

The analytical package is a series of interdependent computer models which use the HPMS sample data as primary input. There are four major models in the analytical process:

- o needs
- o composite index (sufficiency)
- o investment/performance
- o impact assessment

These models are not designed for independent use. Several options are available to perform specific analyses and to provide output for different points in time. The needs and investment/performance models are always used in the analysis process for the analysis of future scenarios whereas the remaining two models may be optionally called

for an analysis of the current highway systems and/or as a part of the analysis of future scenerios. Figure 1 illustrates the analytical process and its outputs.

Needs Model

The needs model simulates the improvements necessary to keep the physical and operational conditions of a highway system from falling below prescribed minimum criteria during the analysis period. Basically, the model (1) identifies individual highway section deficiencies which occur during the analysis period, (2) determines logical improvement types to correct these deficiencies, (3) estimates the costs of the improvements, and (4) modifies the section record to reflect performance in the analysis year, with and without improvement. The analysis period for this process may be a single time period of up to 20 years (investment level analysis) or it may be one of up to four separate funding periods (funding period analysis) within the overall analysis period. In the latter case, each period is analyzed separately.

Deficiency Determination - Each highway section is analyzed independently for each analysis cycle (cycles may be 1 or more years) starting with the year for which data are reported, continuing until a deficiency is identified or the last year in the analysis period is reached. Section deficiencies are identified through comparison of existing or projected conditions with minimum tolerable conditions (MTC) established for physical conditions, geometry, and operational characteristics. These minimum conditions vary by functional class (and rural terrain type and average annual daily traffic (AADT) group) and are selected to reflect a general consensus on the lowest level of performance the public would or should tolerate. MTC's represent an adequate or acceptable level of performance for existing or projected traffic while recognizing that it is not realistic to identify a section as being deficient if the facility is providing reasonably good service. Table 2 contains one possible set of MTC's and design standards for the rural other principal arterial functional system. A set of reduced MTC's are provided for later demonstration of the consequences of reducing MTC's.

The data elements representing the section's conditions and operating characteristics in the first year of the analysis period are compared to the MTC's to determine if a deficiency already exists. If a section is tolerable in the initial or base year, it is examined for future deficiencies. Future conditions (forecast AADT, deteriorated pavement condition, and operating speed and/or volume-to-capacity (V/C) ratio) are simulated for each analysis cycle and compared to MTC's. Sections are deficient if any of the following items do not meet the MTC's:

- o peak hour operating speed or (V/C) ratio
- o lane width
- o pavement condition
- o rural horizontal or vertical alignment adequacy (rural only)

When a pavement deficiency which can be overcome by resurfacing is identified, the deficiency analysis cycles ahead a specified number of cycles to see if a more major deficiency occurs. If so, the pavement deficiency is ignored in favor of the more serious deficiency.

Improvement Analysis - The improvement type selected by the needs model depends upon the combinations of deficiencies identified as occurring on the section being

analyzed. Table 3 contains typical rural deficiencies and the resultant improvement types simulated by this analysis. This table does not contain the complete improvement selection logic.

Improvements sufficient to carry 20-year traffic are made to design standards but may be constrained due to reported widening restrictions. If widening is not feasible, improvements are restricted to maintaining the existing pavement and roadway structure and traffic engineering improvements. Once the improvement types are selected, the capital improvement (right-of-way plus construction) costs are calculated using unit improvement type costs which vary by functional class, number of lanes after improvement and terrain in rural areas and design type, number of lanes after improvement, and type of development in urban areas. Table 4 illustrates the major output of the needs model and miles and cost by improvement type for both high and reduced MTC's. By reducing the MTC's, the miles of improvements by type of improvement have greatly changed as have the needs (a 71-percent reduction). However, the number of miles improved has only been reduced by 13 percent. The needs model also projects the analysis year conditions with and without improvements and places this information on the section record. This information is the primary input to the investment performance model where decisions are made as to what improvements will be made under different investment levels.

Composite (Sufficiency) Index Model

The composite index model evaluates highway condition, safety (geometry), and service (usage and operating characteristics) on a section-by-section basis and aggregates these section evaluations by functional system. These evaluations are in the form of composite and component indexes. Section indexes are similar to sufficiency ratings. A rating between 0.0 and 1.00 is given to each data item evaluated and is applied to the total points assigned to the data item. For example, a pavement condition of 2.5 may warrant a factor of 0.4. In this case, multiply 0.4 x 15 which yields 6 points out of a possible 15 points. The portion assigned to each of the three components may vary by functional class. For example, for rural principal arterials, weighting points of 30 for condition, 30 for safety, and 40 for service may be assigned. A composite index of 100 represents a section with no defects and a lesser total represents the degree of deficiency. Each component and subcomponent and its assigned point value are listed below:

CONDITION (30)	SAFETY (30)	SERVICE (40)
Pavement Type (10)	Lane Width (10)	Operating Speed (20)
Pavement Condition (15)	Shoulder Width (5)	V/C Ratio (10)
Drainage Adequacy (5)	Median Width (5)	Access Control (10)
	Alignment Adequacy (10)	

Weighted component and composite indexes by functional system, and mileage and travel distributions by component and composite are provided if desired.

Investment Performance Model

The investment/performance analysis provides the means for relating investment to future highway performance in terms of composite index values and as summaries of

certain physical features and operating conditions--the first significant output of the analytical package. This analysis first determines priority rankings for all proposed improvements by functional system and area (rural, small urban and urbanized) based on user-specified ranking factors. Potential improvements can be ranked using one of several methods. The most commonly used method is the cost effectiveness index (CEI) calculated by the model.

CEI = (0.5 (100 + TYCI) - COMP) x .5 (TYADT + IYADT) x EVAL x LENGTH/COST

where:

TYCI = target year composite index

COMP = base year composite index (maximum of 70.0)

TYADT = target year AADT

IYADT = improvement year AADT

EVAL = economic life for improvement type by improvement surface type

LENGTH = length of section

COST = cost of improvement

Upon completion of the ranking process, the improvements are selected and improved analysis year conditions for the simulated improvement are summarized from the top of the priority list downward until the funds for the given investment level are exhausted. At that point, the summarization process is continued using analysis year unimproved conditions for the remaining sections because funds are no longer available to support the potential improvements. This process is applied separately for each functional system by area (rural, small urban, and urbanized). The output from this analysis consists of a series of summary tabulations. Summary tabulations are produced for each investment level or funding period. Summaries are provided for composite index values, pavement types and conditions, lane widths and cross sections, V/C ratios, and peak hour operating speeds. Also shown are the mileage and cost of investment (both funded and not funded) by functional type and improvement type. Table 5 illustrates the output of this analysis in terms of 1995 conditions for investments equal to full needs for the high and reduced MTC's. (Reduced MTC's concentrate investments on pavement problems; thus producing much higher system pavement conditions for much less money at the expense of increased congestion.) The 1995 conditions with no investment are also shown. Figure 2 illustrates one method for presenting investment performance information--the investment curve. By plotting the systemwide composite index versus various investment levels, a curve is produced which enables one to assess the investment necessary to achieve certain conditions.

Impact Assessment Model

The purpose of this section of the modeling process is to convert existing and future highway physical and operating conditions into user cost factors. Because a primary reason for highway investment is to reduce user costs, this impact assessment methodology was developed to supply the benefit portion of the cost/benefit ratio.

The calculated user cost factors are expressed in terms of rates. The factors include fuel consumption, vehicle emissions (carbon monoxide, hydrocarbons, and nitrogen oxide), vehicle operating costs, average overall travel speeds, and three types of accidents--

property damage only, nonfatal injury, and fatal. With these factors, comparisons can be made between today's highway performance and future performance levels achieved with various investment levels and investment strategies. The comparisons can then be used to determine the relationships that exist between investment, travel, user costs, and improvement types.

Input - The primary input to the impact assessment model is sample inventory data (see Figure 1). Analyses of base or inventory year physical and operating conditions use these data as reported. Analyses of future target or analysis year user cost factors use the inventory data modified by the needs and investment/performance analysis models described earlier to reflect analysis year conditions. Individual sections will have analysis year conditions reflecting improvements simulated, if any, as a result of investments made.

Analysis Process - The impact assessment model analyzes physical and operational conditions in the inventory year or a future analysis year and produces user cost factors indicative of either the conditions that exist in the inventory year or the conditions that are expected to exist in the analysis year as a result of the assumptions made in the needs and investment/performance analyses. Each sample, expanded to represent its portion of the universe, is individually analyzed, and individual section user cost factors are weighted together to produce functional system user cost factors or performance measures.

The logic of the analytical process is built around a series of tables, curves, and equations developed by the FHWA through in-house or contract research efforts. These components of the process can be changed when updated or improved data or relationships are available. The major components are:

1. Daily Distributions of Traffic by Functional Class and Design Type (2) - For selected combinations of functional class and design type (freeway, multilane, and 2 or 3 lane, etc.) sets of from 3 to 12 percentages are provided for stratifying the AADT into daily increments experiencing relatively homogeneous congestion. The appropriate daily distribution (set of percentages) is chosen as a function of the relative daily congestion expressed by the AADT to capacity ratio. These relationships were developed in-house by FHWA and are based upon automatic traffic recorder data.
2. Speed Estimating Relationships by Design Type and Congestion Level (2) - Initial running speeds are provided for each congestion level for representative design types as a function of speed limit, average highway speed or weighted design speed, number of lanes, and percent sight distance where appropriate. The initial running speed is modified to reflect the extent of curves and grades, pavement conditions, idling time, and the number of speed change cycles, unique to each highway segment.
3. Speed Adjustment Relationships - The following speed adjustment relationships were developed in-house by FHWA:
   - Pavement Condition (2) -Speeds for all vehicles are adjusted as a function of pavement serviceability rating (PSR) to reflect the effects of pavement condition. Different relationships for freeways and nonfreeways and different surface or pavement types are used.

- Alignment (2) - Speeds on curves are not allowed to exceed the safe speed or design speed for the curve class. Truck speeds are reduced for positive grades of a certain magnitude. If the length of grade exceeds a specified length the trucks reach crawl speed and continue on the grade at the crawl speed. Lengths of grades to reach crawl speed and crawl speeds vary for the four HPMS truck types. Speeds on negative grades are increased back to the initial running speed if the entry speed was lower than the initial running speed.

4. Speed Change Cycle, Stop Cycle, and Speed Change Magnitude Estimating Relationships (2) - Based on the initial running speed and design type of the section, the number and magnitude of speed change cycles and stop cycles experienced are estimated. Relationships were developed in-house by FHWA using data available from previous research.
5. Idling Time Relationships (2) - Based on the design type of the section and the relative congestion, a percentage of total traveltime spent idling is determined. Idling time relationships were developed by the FHWA using data available from previous research.
6. Vehicle Operating Costs Tables and Fuel Consumption Tables for Pavements in Good Condition (PSR = 4.5) (2, 3)

- Unit Fuel Consumption and Vehicle Operating Cost on Grades by Vehicle Type and Running Speed
- Excess Unit Fuel Consumption and Vehicle Operating Cost on Curves by Vehicle Type and Running Speed
- Excess Unit Fuel Consumption and Vehicle Operating Costs for Speed Change and Stop Cycles By Vehicle Type, Running Speed, and Final Speed
- Excess Unit Traveltimes for Speed Change and Stop Cycles By Vehicle Type, Running Speed, and Final Speed
- Unit Idling Fuel Consumption and Vehicle Operating Costs by Vehicle Type

These tables were developed for FHWA by the Texas Research and Development Foundation (TRDF) under contract DOT-FH-11-9678.

7. Pavement Condition Adjustment Factors for Vehicle Operating Costs and Fuel Consumption (2) - Vehicle operating costs and fuel consumption rates from tables are adjusted using these factors to reflect PSR's other than 4.5. Factors were developed in-house by FHWA using the TRDF data and other related research.
8. Vehicle Classification Data by Area and Functional Class (4) - Data from the HPMS Vehicle Classification Case Study were used to develop rural and urban vehicle type distributions by functional class for the seven impact analysis vehicle types.
9. Emissions Rates for Carbon Monoxide, Hydrocarbons, and Nitrogen Oxide by Vehicle Type and Calendar Year (5) - These data were obtained from tabulations of selected low-altitude vehicle emission factors, assuming 20-percent cold starts and an ambient temperature of 60 degrees from EPA's Mobile Source Emission Factors, dated March 1978.

10. Total, Fatal, and Injury Accident Rates by Design Type, and AADT Carried (2) - These tables were developed by the FHWA using available data from research efforts.

Specifically each section is analyzed as follows (see Figure 3 for flowchart of analytical process):

1. The average AADT is stratified into 3 to 12 daily increments experiencing relatively uniform congestion to more accurately represent daily vehicle operations and the required user cost factors. Each congestion period is analyzed independently and the resulting user cost factors are weighted together to develop factors for each vehicle type representative of the overall average day.
2. For each congestion period an initial unadjusted running speed free of the effects of pavement condition, speed changes, curves and grades, and idling time for specific design types is established.
3. Within a congestion level, the AADT is stratified into seven vehicle types:
   small autos (less than 3,000 pounds)
   large autos (greater than 3,000 pounds)
   pickups and vans
   two-axle, six-tire, single-unit trucks
   three or more axle, single-unit trucks
   three- or four-axle, multiunit trucks
   five or more axle multiunit trucks

The number of each vehicle type in the average day is determined as a function of the reported percent trucks and vehicle classification data for each rural and urban functional class. Each vehicle type is independently processed for a given congestion period.

4. The initial running speed for a given congestion period is adjusted to reflect the pavement condition of the section being analyzed.
5. The emission measures (CO, HC, and NO_x) are calculated as a function of the year being analyzed, vehicle type, and the running speed adjusted for pavement condition.
6. The running speed adjusted for pavement condition is then used to calculate the number of speed change cycles for autos, single-unit trucks, and multiunit trucks and the magnitude of these speed change cycles. Likewise, the number of stop cycles experienced is calculated.
7. The running speed, which has already been adjusted for pavement condition, is then adjusted for curvature by using the safe speed for each curve class. If the running speed exceeds the safe speed of a curve, the safe speed becomes the running speed for that part of the section. The calculated running speed is used as the vehicle operating cost and fuel consumption table entry speed for automobiles, panels, and pickups. This same running speed is then used to determine the truck table entry speeds for the reported grades as a function of the running speed, the length of grade, and the crawl speed.
8. Using the table entry speeds calculated for each grade class, the unit vehicle operating cost and fuel consumption rates are interpolated from the appropriate

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grade tables and used to calculate the fuel consumption and vehicle operating costs for grades for the section. A similar procedure is used to determine the excess fuel consumption and vehicle operating costs for curves using table entry speeds adjusted for curvature. The excess operating costs and fuel consumption rates for curves are added to values for grades to get the vehicle operating costs for curves and grades.

9. Using the running speed adjusted for pavement condition as an initial table entry speed and the magnitude of the speed change cycle, the excess vehicle operating costs, fuel consumption rates, and traveltimes for a speed change cycle and stop are determined by interpolating from the appropriate tables. By multiplying the appropriate unit values by the numbers of speed change cycles and stops, the excess operating costs, fuel consumption, and traveltimes associated with speed change cycles and stop cycles for the section and congestion level are determined. The excess costs and fuel consumption are added to the like values for curves and grades.
10. The vehicle operating costs and fuel consumption rates for curves, grades, speed change cycles, and stops are modified to reflect pavement conditions other than 4.5.
11. The amount of time spent idling is calculated. Then the vehicle operating cost and fuel consumption associated with idle time are calculated and added to similar values for curves, grades, speed change cycles, and stops to get the section totals for these items.
12. The total traveltime is based on the initial running speed adjusted for pavement condition, curves, grades (trucks), speed change cycles, and stops plus the idling time. The overall travel speed is calculated as the vehicle miles of travel divided by the traveltime.
13. The accident measures (fatal accidents, injury accidents, and property damage accidents) are calculated as a function of traffic volume, design type, and vehicle miles of travel on the section.
14. This process is repeated until all vehicle types and congestion period traffic volumes are complete. Vehicle type values are accumulated for all congestion levels.
15. Final user cost factors are calculated and output.

Output - Examples of the all-vehicle output (vehicle operating costs) for the rural principal arterial system are illustrated as investment performance curves in Figure 4. This figure illustrates that user cost factors may be used as a tool for assessing the consequences of different investment levels under different assumptions.

CONCLUSION

The analytical process described here, has been developed to provide a tool for predicting the economic and environmental effects of current and future highway investment options. It is essential that decisionmakers be aware of the interactions among several dynamic factors, including highway user costs, changing highway performance, capital investment in highways, and highway travel demand.

This process defines the interaction between highway investment and future highway performance and user costs. Unfortunately, the interaction of future highway performance with future highway travel is currently beyond the scope of this process. With continued use the efficiency, flexibility, and predictive ability of this methodology will improve.

Investments for capital improvements on U. S. highways have been at the $15 billion level in recent years. Investments of this magnitude, approaching 1 percent of the GNP, have a substantial impact on the labor force and many industries, and have a ripple effect throughout the economy. The effect of investments of this magnitude and the resulting changes in system performance must be understood, and should be analyzed. At present, the HPMS analytical process has been in use only a short time. Over the next few years the process will be fine tuned, providing the Nation's highway system with a better current and projected condition inventory than most, if not all, public-owned property in the United States.

Interfacing these products with currently available economic analysis and econometric forecasting tools will permit economic impact analyses on various sectors of the economy, including highway users, the contruction industry, and related industries. Cost-benefit analyses of alternatives will improve as the predictive ability improves.

ACKNOWLEDGEMENTS

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1. Highway Performance Monitoring System, Field Manual for the Continuing Analytical and Statistical Data Base, U. S. Department of Transportation, Federal Highway Administration, Office of Highway Planning, September 1980.
2. Highway Performance Monitoring System Analytical Process, Volume II - Technical Manual, U. S. Department of Transportation, Federal Highway Administration, Office of Highway Planning, To Be Published February 1983.
3. Vehicle Operating Costs, Fuel Consumption and Pavement Type and Condition Factors, U. S. Department of Transportation, Federal Highway Administration, Office of Highway Planning, June 1982.
4. Highway Performance Monitoring System, Vehicle Classification Case Study, U. S. Department of Transportation, Federal Highway Administration, August 1982.
5. Tabulation of Selected Low-Altitude Vehicle Emission Factors Based on EPA's Mobile Source Emission Factors Dated March 1978, Noise and Air Quality Branch, Office of Environmental Policy, Federal Highway Administration, September 1978.

Table A-1
Sample Section Inventory Data

Identification
State Code
County Code
Rural/Urban Designation
Urbanized Area Code **
Expansion Factor

System/Jurisdiction
Functional Class

Operation/Travel
Type of Facility
Section/Group Length
Current and Future AADT
Number of Through Lanes
Speed Limit
Average Highway Speed *
K-Factor
Directional Factor
Capacity
Signal Type and Timing **
Parking
Percent Trucks (Peak and Off-Peak)

Pavement
Surface/Pavement Type
Pavement Section
SN or Slab Thickness
Pavement Condition

Geometry/Configuration
Access Control
Lane Width
Approach Width **
Shoulder Type and Width
Median Type and Width
Horizontal and Vertical Alignment
% Sight Distance *

Supplemental
Drainage Adequacy
Type of Terrain *
Type of Development
Urban Location **
No. of Intersections

* Rural Data Item
** Urban Data Item

Table A-2
Rural Principal Arterial
Minimum Tolerable Conditions

	HIGH			REDUCED		
TERRAIN[1]	F	R	M	F	R	M
Lane Width	11	11	11	10	10	10
Right Shoulder Width	8	8	6	6	6	4
Shoulder Type	Stablized			Stablized		
Pavement Condition	2.6	2.6	2.6	2.1	2.1	2.1
Operating Speed (Peak Hour)	55	50	45	20	20	15
Volume to Capacity Ratio	0.70	0.70	0.70	0.99	0.99	0.99
Surface Type	High Type[2]			High Type[2]		
Horizontal Alignment Adequacy[3]	2	2	2	4	4	4
Vertical Alignment Adequacy[3]	2	2	2	4	4	4

	DESIGN STANDARDS		
TERRAIN[1]	F	R	M
Lane Width	12	12	12
Right Shoulder Width	12	10	8
Surface Type	High		
Median Width	64	64	16
AHS (Weighted Design Speed)	70	70	55

1/ F = Flat, R = Rolling, M = Mountainous

2/ High Type - High Rigid and Flexible Pavements, Pavement/Surface Codes 60, 70, and 80 as Defined in HPMS Field Manual

3/ Alignment Adequacies - One (Good) to Four (Poor) Rating of Alignment Adequacy as Defined in HPMS Field Manual

Table A-3
Typical Rural Deficiencies and Improvement Type

DEFICIENCY TYPES AND COMBINATIONS	RESULTING IMPROVEMENT TYPES
Access Control & Operating Speed or V/C Ratio (Interstate & High Volume Principal Arterials Only)	Reconstruct to Freeway
Operating Speed* or V/C Ratio* If Widening Not Feasible	Major Widening No Improvement
Operating Speed* or V/C Ratio* & Pavement Condition less than R** or Alignment If Widening Not Feasible	Reconstruct With More Lanes Reconstruct As Is
Lane Width If Widening Not Feasible	Minor Widening No Improvement
Lane Width & Alignment or Pavement Condition less than R** If Widening Not Feasible	Reconstruct With Wider Lanes Reconstruct As Is
Pavement Condition less than R**	Pavement Reconstruction
Alignment	Isolated Reconstruction
Pavement Condition less than MTC less than R** & Shoulder Type or Width	Resurfacing and Shoulder Improvement
Pavement Condition less than MTC less than R**	Resurfacing

* Operating speed and V/C ratio are for peak hour.

** PSR below which reconstruction needed.

Table A-4
Rural Other Principal Arterial*
Miles & Costs by Improvement Type
(Costs in Millions)

	HIGH MTC'S		REDUCED MTC'S	
IMPROVEMENT TYPE	MILES	COSTS	MILES	COSTS
Reconstruct To Freeway	8,546	18,845	447	1,263
Reconstruct With More Lanes	1,221	2,568	24	56
Reconstruct With Wider Lanes	2,334	2,964	68	77
Reconstruct As Is	138	95	0	0
Isolated Reconstruction	5,349	2,940	0	0
Major Widening	3,953	5,228	57	91
Minor Widening	5,437	2,928	881	483
Resurfacing With Shoulder Improvement	15,009	3,066	20,715	4,131
Resurfacing	19,074	3,447	31,041	4,584
Pavement Reconstruction	2,661	2,467	2,146	2,052
TOTAL	63,722	44,548	55,379	12,737
No Improvement	1,755		10,098	

* Based on 1978 HPMS data for 40 States.

Table A-5
Investment/Performance 1995 Conditions
Rural Other Principal Arterial
(Percent of Mileage; Weighted by Mileage)

	HIGH MTC'S	REDUCED MTC'S	NO IMPROVEMENT
Pavement Type - High:	100	100	90
Pavement Condition - PSR:			
2.0	7	0	82
2.0 to 2.9	4	14	16
3.0 to 3.9	63	36	2
3.9	26	50	0
Lane Width 11:	99	93	92
Cross Section Undivided:	61	81	81
V/C Ratio:			
.41	87	74	72
.41 to .80	11	21	21
.80	2	5	7
Operating Speed:			
40	4	12	13
40-49	10	20	20
49	86	68	67
Composite Index:	83.7	78.3	64.9
Condition	26.4	27.4	15.7
Safety	27.9	26.0	24.9
Service	29.3	24.9	24.3

FIGURE A-1

1982
HPMS ANALYTICAL PACKAGE

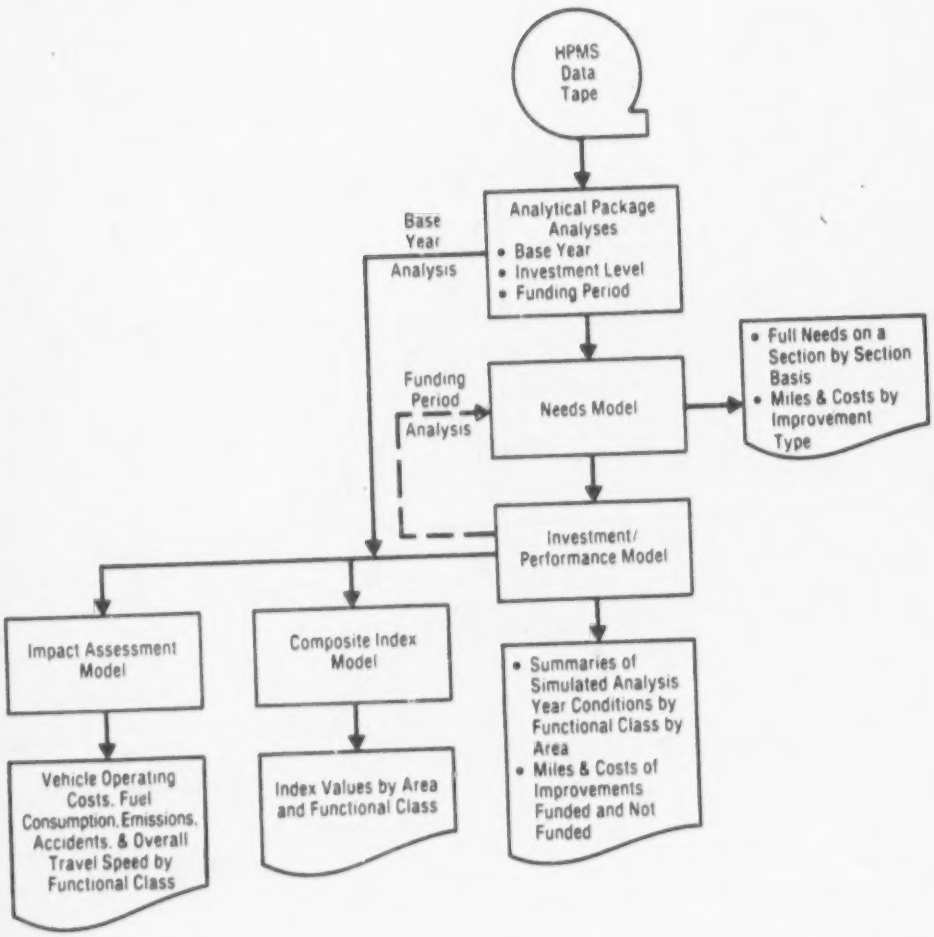

HPMS Data Tape
Analytical Package Analyses
• Base Year
• Investment Level
• Funding Period
Base Year Analysis
Funding Period Analysis
Needs Model
• Full Needs on a Section by Section Basis
• Miles & Costs by Improvement Type
Investment/ Performance Model
Impact Assessment Model
Composite Index Model
Vehicle Operating Costs, Fuel Consumption, Emissions, Accidents, & Overall Travel Speed by Functional Class
Index Values by Area and Functional Class
• Summaries of Simulated Analysis Year Conditions by Functional Class by Area
• Miles & Costs of Improvements Funded and Not Funded

FIGURE A-2

INVESTMENT PERFORMANCE CURVES
RURAL OTHER PRINCIPAL ARTERIAL SYSTEM
1995 COMPOSITE INDEX VS. DOLLARS INVESTED

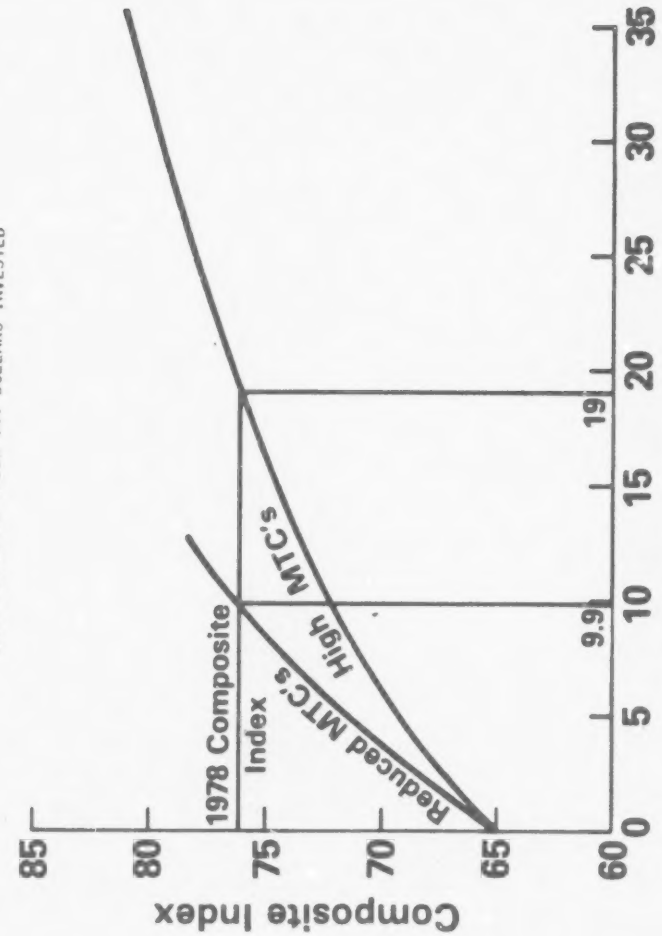


FIGURE A-3

HPMS ANALYTICAL PROCESS --

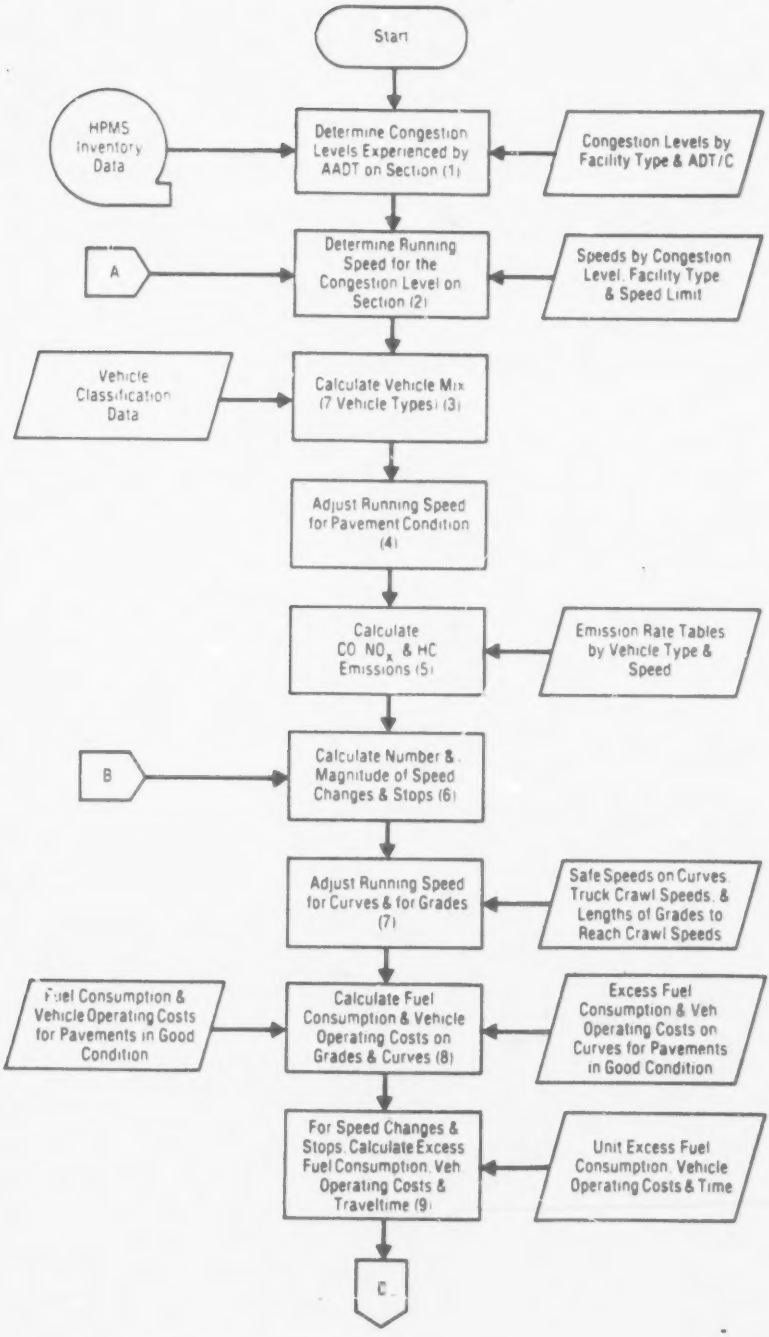

Start
HPMS Inventory Data
Determine Congestion Levels Experienced by AADT on Section (1)
Congestion Levels by Facility Type & ADT/C
A
Determine Running Speed for the Congestion Level on Section (2)
Speeds by Congestion Level, Facility Type & Speed Limit
Vehicle Classification Data
Calculate Vehicle Mix (7 Vehicle Types) (3)
Adjust Running Speed for Pavement Condition (4)
Calculate CO NO_x & HC Emissions (5)
Emission Rate Tables by Vehicle Type & Speed
B
Calculate Number & Magnitude of Speed Changes & Stops (6)
Adjust Running Speed for Curves & for Grades (7)
Safe Speeds on Curves, Truck Crawl Speeds, & Lengths of Grades to Reach Crawl Speeds
Fuel Consumption & Vehicle Operating Costs for Pavements in Good Condition
Calculate Fuel Consumption & Vehicle Operating Costs on Grades & Curves (8)
Excess Fuel Consumption & Veh Operating Costs on Curves for Pavements in Good Condition
For Speed Changes & Stops, Calculate Excess Fuel Consumption, Veh Operating Costs & Traveltime (9)
Unit Excess Fuel Consumption, Vehicle Operating Costs & Time
C

FIGURE A-3 (continued)

HPMS ANALYTICAL PROCESS

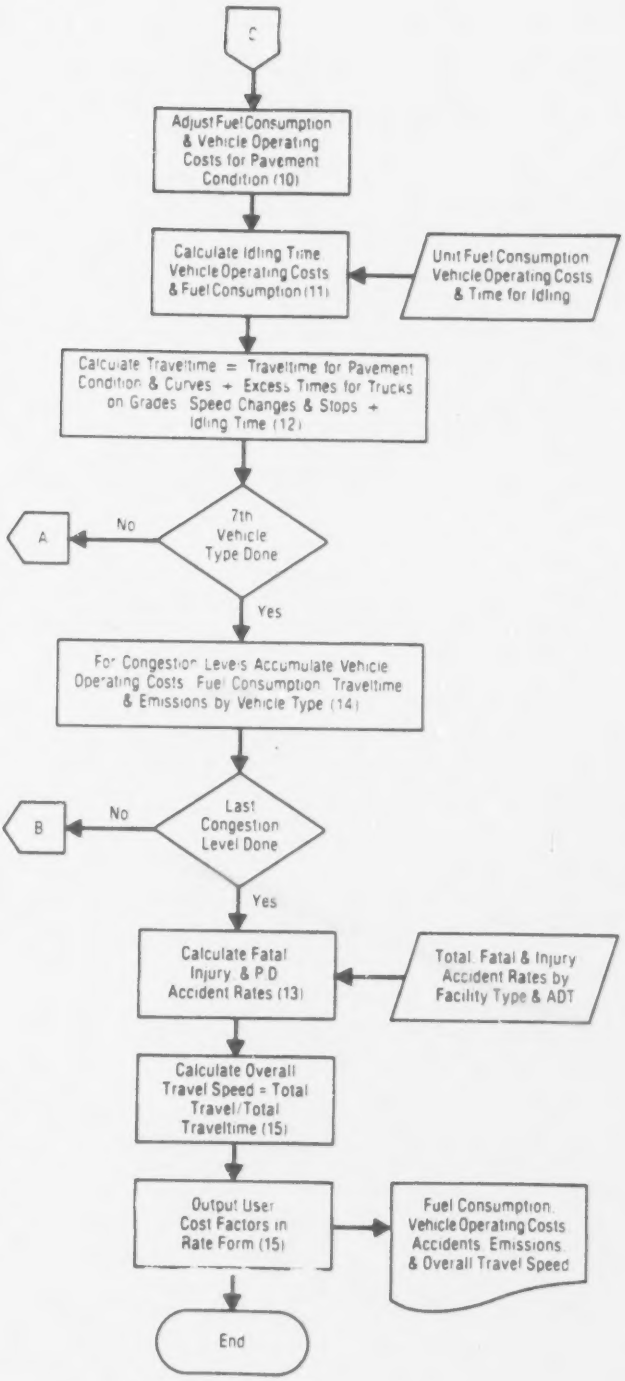
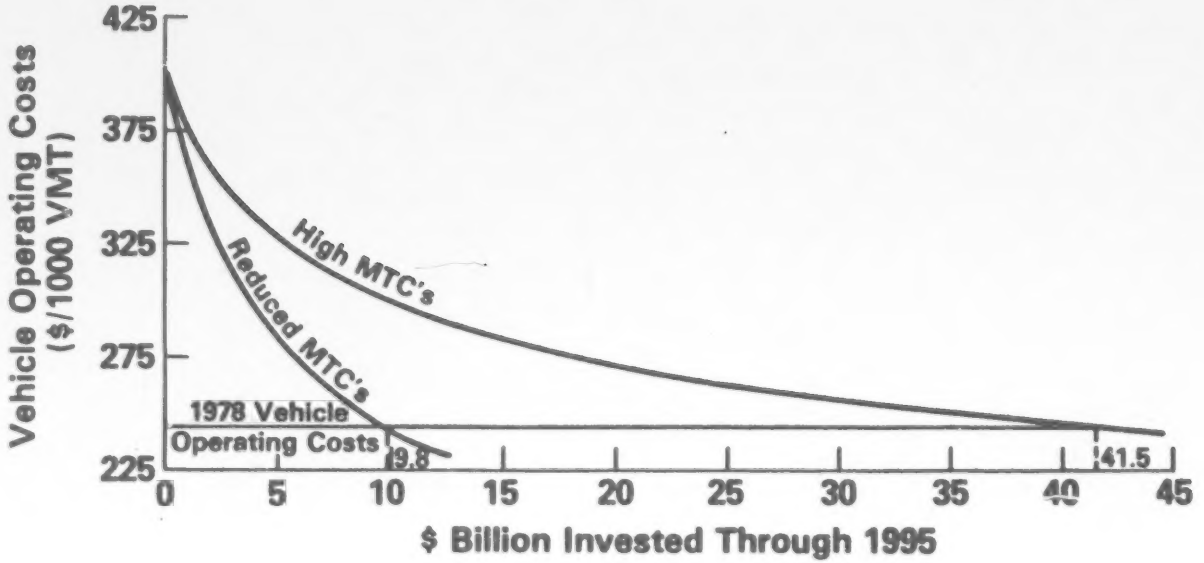

C
Adjust Fuel Consumption & Vehicle Operating Costs for Pavement Condition (10)
Calculate Idling Time Vehicle Operating Costs & Fuel Consumption (11)
Unit Fuel Consumption Vehicle Operating Costs & Time for Idling
Calculate Traveltime = Traveltime for Pavement Condition & Curves + Excess Times for Trucks on Grades Speed Changes & Stops + Idling Time (12)
7th Vehicle Type Done
No
A
Yes
For Congestion Levels Accumulate Vehicle Operating Costs Fuel Consumption Traveltime & Emissions by Vehicle Type (14)
Last Congestion Level Done
No
B
Yes
Calculate Fatal Injury & P.D. Accident Rates (13)
Total Fatal & Injury Accident Rates by Facility Type & ADT
Calculate Overall Travel Speed = Total Travel/Total Traveltime (15)
Output User Cost Factors in Rate Form (15)
Fuel Consumption Vehicle Operating Costs Accidents Emissions & Overall Travel Speed
End

FIGURE A-4

INVESTMENT PERFORMANCE CURVES
RURAL OTHER PRINCIPAL ARTERIAL SYSTEM
1995 VEHICLE OPERATING COSTS VS. DOLLARS INVESTED
(ALL VEHICLES)